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CORRIGENDA.

In Plate I. *for* fig. 6 *read* fig. 9, *and for* fig. 9 *read* fig. 6. The description of the figures in p. 57 will then be correct.

In the Rev. R. Boog Watson's paper on Cerithiopsides, the Author desires that C. CONCATENATA, Corti, Foss. de Monte Mario, pp. 32, 51, be substituted for "C. JEFFREYSI, Wats.," in page 90, thirteenth line from bottom. Also that in Plate IV. fig. 2, *concatenata* be substituted for *Jeffreysi*, and for "*pulchella*, Jeffr.," in the description of figs. 2, 2*a* of same Plate at page 95, eighth line from top.

THE JOURNAL

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Notes on the Cerebral Convolutions of the Carnivora.

By St. George Mivart, F.R.S., F.L.S., V.P.Z.S.

[Read 18th December, 1884.]

In the year 1834, Sir Richard Owen, in describing * the brain of the Cheetah (*Felis* (*Cynælurus*) *jubata*), took occasion to point out the generally similar disposition of the cerebral convolutions throughout the feline group. The subject has been further treated by him in his 'Anatomy of Vertebrates' †. Considerably before the appearance of the last-named work, MM. Leuret and Gratiolet published descriptions, with admirable illustrations ‡, of the convolutions of a variety of carnivorous mammals, pointing out the characters which are more or less common in, or are peculiar to, four sets of species. M. Dareste also contributed a memoir § on the convolutions of the mammalian brain, one section being devoted to "Types des Carnivores." The late Professor Paul Gervais published ‖, later on, an account of the same structures in a much greater number of carnivorous species, accompanied by numerous figures representing the brains of such species and of

* See Trans. Zool. Soc. vol. i. pp. 133–136, plate xx.

† See vol. iii. p. 116 (1868).

‡ 'Anatomie Comparée du Système nerveux,' with an Atlas (1839–1857).

§ "Circonvolutions du Cerveaux chez les Mammifères," in the Ann. des Sc. Nat. 4e série (1855), tome iv. pp. 73–76, plate ii. figs. 1–8.

‖ "Mémoire sur les formes cérébrales propres aux Carnivores," Nouvelles Archives du Mus. vol. vi. (1870), pp. 103–162, plates iii.–ix.

casts of the interiors of their skulls. A little later, Professor Burt Wilder further elucidated the subject by a paper * giving an account of the cerebrum, with figures, of many varieties of Dogs, as well as of that of *Hyæna*, *Ursus*, and *Procyon*, together with some feline species. In 1880, Julius Krueg † gave forth an elaborate memoir largely on the same subject, by far the most elaborate and complete which has yet appeared, and to which frequent reference will be made. The following year Professor Burt Wilder read before the American Philosophical Society ‡ an elaborate paper on the brain of the Cat—a paper which has its place on the shelves of our Library. Last of all, Mr. Langley has given us § a very complete paper on the brain of the Dog, wherein will be found ‖ references to yet other memoirs relating to the physiology of the subject and to questions of the cerebral homologies of different orders of mammals—questions with which this paper is not concerned.

I am not aware of any other works on the subject than those here directly, or, as above, indirectly, referred to; but there are various isolated descriptions of the brain of different carnivorous mammals, such as those of the late Professor Garrod and of Professor Flower, which will be referred to when the subjects they treat of come to be mentioned. Three of these, however, may be referred to at once ¶, since in them the two Professors give a short summary of such cerebral characters as they believe to be common to the main subdivisions of the Fissipedal Carnivora.

My object in this paper is to point out the leading cerebral characters of many genera of Carnivora, and especially those of certain forms which appear either not to have come under the direct observation of the before-mentioned authors, or not to have had certain characters described which it seems to me desirable to note. I purposely confine myself to the observation of a few characters which I believe to be leading characters, having had

* In the 'Proceedings of the American Association for the Advancement of Science,' 22nd Meeting (Portland, Maine, August 1873), pp. 214–234.

† "Ueber die Furchen auf der Grosshirnrinde der Zonoplacentalen Säugethiere," Siebold's Zeitschrift f. wissen. Zool. vol. xxxiii. (1880), pp. 595–648, plates xxxiv.–xxxviii.

‡ On July 15th, 1881.

§ In the 'Journal of Physiology,' vol. iv. pp. 248–285.

‖ At page 276.

¶ Namely, two papers by Professor Flower, in P. Z. S. 1869, p. 482, and P. Z. S. 1880, p. 73; and one by Professor Garrod, P. Z. S. 1878, p. 375.

forced on me a conviction of the great variability of the more minute details of cerebral conformation. As Professor Burt Wilder remarks *, when the brains of two or three individuals are alone examined, it is easy enough to draw out distinctive characters, many of which, however, a more extended survey soon shows to be worthless. I have been greatly impressed, not only with the variability in the details of the gyri in the same species, but even with the differences which every now and then present themselves in the two sides of the brain of the very same individual. Nevertheless, in spite of the great variability referred to as to matters of detail, I am convinced that the characters on which I lay stress have a taxonomic value, and some of them appear to me also to possess a certain phylogenetic interest and significance.

CYNOIDEA.

The brains, not only of all Dogs, but of all the animals which together constitute the suborder Cynoidea †, are as a rule singularly uniform as regards those points of structure with which the present paper is concerned. I have examined the brains of various domestic Dogs, of the Fox, Jackal, the common Wolf, the Red Wolf, *Canis Azaræ*, *C. microtis*, and the singular Raccoon-like Dog, *C. procyonoides* (type of the proposed genus *Nyctereutes*), as also of *Icticyon venaticus*, *Lycaon pictus*, and *Otocyon megalotis*, availing myself in the study of this, as of every other group, of the rich and yearly increasing stores preserved in the Museum of the Royal College of Surgeons.

The cerebral characters which have been pointed out before as common to the Canidæ I have found uniformly present, save

* Proc. of Amer. Assoc. for the Advancem. of Sci. p. 233. He says:—"After a pretty careful study of the specimens and works at my command, I feel justified in asserting that we cannot as yet characterize the fissural pattern of any Mammalian order, family, genus, or even species without the risk that the next specimen will invalidate our conclusion." He advocates, p. 232, a study of the variation presented by the two sides of the brain of the same individual in order to obtain "a test of the value of the differences observed amongst brains." Such a study might be thus useful; but it does not come within the scope of the present paper.

† See Leuret, *l. c.* vol. i. pp. 373–378, plate iv.; Dareste, *l. c.* p. 74, fig. 1; P. Gervais, *l. c.* pp. 107–119, plates i., ii., and figs. 1–7, plate iii.; Burt Wilder, *l. c.* pp. 214–248, with many figures of varieties, plates i.–v.; Krueg, *l. c.* pp. 612–617, plate xxxiv.; and Langley, *l. c.* pp. 248–280, woodcuts, figs. 1–3, and plates vii. & viii.

on one side of the brain of one species. In every case the Sylvian fissure is embraced by four successive circum-Sylvian convolutions, which, for my present purpose, I shall distinguish by four simple designations. The two lowest gyri I shall distinguish as the *Sylvian* gyri (a term already in use), that next the Sylvian gyrus being called the *first* and the adjoining one above, the *second* Sylvian gyrus. The third gyrus from the Sylvian fissure I shall designate the *parietal gyrus*, and the next, and uppermost one, will be spoken of as the *sagittal gyrus*, since it lies in close proximity to the sagittal crest and suture. In every case I found the two Sylvian sutures well separated and distinct, save on one side of the brain of *Icticyon venaticus*, where the posterior limb of the first Sylvian gyrus was rudimentary *. Professor Burt Wilder, however, figures seven instances in which he found the separation between the Sylvian gyri incomplete in domestic Dogs †. In every case, without exception, I found the posterior limb of the parietal gyrus to be subdivided by a longitudinal sulcus, so that it bifurcated backwards. Prof. Burt Wilder observes that this bifurcation sometimes extends to the anterior end of the parietal gyrus ‡.

In every case I find that there is, on the inner surface of each cerebral hemisphere, a direct continuation of the calloso-marginal sulcus into the crucial sulcus, thus cutting off what is known as the hippocampal gyrus from the sagittal gyrus. In no case do I find, when the dorsum of the brain is looked at, that there is any sulcus proceeding forwards and inwards in front of the crucial sulcus of one hemisphere towards a similarly situated sulcus in the other hemisphere. Nothing of the kind is indicated in any figure of a Cynoid brain which I have seen. Sometimes (as I find in *C. Azaræ*, *C. microtis*, and *Lycaon pictus*) the sagittal gyrus is longitudinally grooved, as is also its inner side in *Lycaon* and some domestic Dogs.

* A fact duly noted by Professor Flower in his paper on the anatomy of that animal in the P. Z. S. 1880, pp. 73–76, figs. 6 & 7. The number of this specimen in the Physiological series of preparations in the Museum of the Royal College of Surgeons is 1325 L. *d*.

† See *l. c.* figs. 12 & 13, Terrier, 16, Greyhound, and 20 to 24, Pomeranian Dogs (the animal the brain of which is represented in fig. 20 being the mother of those the brains of which are represented in figs. 21, 22, & 23), and, lastly, fig. 25, an English Terrier.

‡ *L. c.* p. 231, and the figures 12, 21, and 22.

Felidæ.

A similar but different uniformity prevails amongst the extensive group of Cats *, whether of the largest or smallest species though, as has been again and again remarked, the larger the species the more convoluted the gyri; especially is this the case with the fourth or uppermost gyrus. Small bridging convolutions have been observed † connecting the sagittal and parietal gyri. They, however, are very inconstant; but there is a constant, more or less extensive connection between the parts answering to the two Sylvian gyri of the Dog. Thus in every Cat there is a very broad gyrus next the Sylvian fissure, either limb of which is grooved by a more or less vertical sulcus, which is the rudimentary representative of the sulcus which completely separates the two lowest circum-Sylvian gyri of the Dog. The second distinguishing character common to the whole of the Felidæ, so far as I have been able to observe, is the non-bifurcation (or subdivision by a longitudinal groove) of the parietal gyrus. The third universal character is the continuation of the hippocampal gyrus forwards and upwards to blend, behind the crucial sulcus, with the sagittal gyrus, the hinder end of the crucial sulcus being thus separated off from the anterior end of the calloso-marginal sulcus by the ascending bridge of convolution from the hippocampal gyrus. Sometimes the, always very conspicuous, crucial sulcus is placed very far forwards ‡. It is always simple, as in the Dogs.

The genera which compose the other families of Carnivora differ so in the details of their cerebral structure as to demand separate notice.

Viverra.—The Civet § has the parts which answer to the two lowest circum-Sylvian gyri of the Dog still more completely blended together than they are in the Cats. The single Sylvian

* See Leuret, *l. c.* vol. i. p. 378, plate v.; Dareste, *l. c.* p. 74, figs. 3 & 4; and P. Gervais, *l. c.* p. 119, and plate ix. fig. 7. See 'The Cat' (published by John Murray). pp. 268 & 269, figs. 125, 126, 127. "The Brain of the Cat," by Professor Burt Wilder, a paper read before the American Phil. Soc., July 15th, 1881, four plates; also Krueg, *l. c.* pp. 547–622, and plate xxxv.

† By MM. Leuret and Gratiolet.

‡ As in the Cheetah. See P. Gervais, *l. c.* plate ix. fig. 7, and Owen, Trans. Zool. Soc. vol. i. plate xx.

§ See Leuret, *l. c.* p. 378; P. Gervais, p. 128, pl. ix. fig. 5. See also P. Z. S. 1882, p. 516; Krueg, *l. c.* p. 625, plate xxxvi.

gyrus thus formed has its pre-Sylvian limb sometimes much broader, sometimes narrower than that behind the Sylvian fissure, and it is more or less vertically grooved, the groove being a remnant of that sulcus in the Dog which separates its first and second Sylvian gyri one from the other. The gyrus next above the parietal gyrus (answering to the third from the Sylvian fissure of the Dog) is simple, and not only differs from the corresponding gyrus of the Dog in being undivided, but also in being shorter, the sulcus between it and the sagittal gyrus not extending so far backwards. The hippocampal gyrus is separated off from the sagittal by the continuation forwards and upwards of the calloso-marginal sulcus, as in the Dogs. The most striking difference presented by the upper surface of the Civet's cerebrum, when compared with the cerebrum of any of the Carnivora here before referred to, is the minute size of the crucial sulcus—a sulcus so conspicuous in all the Felidæ and Canidæ. It is with this minute crucial sulcus that the calloso-marginal sulcus unites.

Genetta.—The Genet's * brain is like that of the Civet, still further simplified. It agrees with the latter save that the Sylvian gyrus shows less traces of its subdivision into two circum-Sylvian gyri than in the Cats (the single Sylvian gyrus being almost smooth), and that the crucial sulcus is much more rudimentary still, being only indicated, on the dorsal surface of the cerebrum, by a minute notch.

Nandinia.—The brain of this exceptional form † is quite like that of *Genetta*, save that the Sylvian gyrus more resembles the same part in *Viverra.*

Paradoxurus.—The brain of the palm-Cats ‡ has the hinder limb of the Sylvian gyrus twice the size of its anterior limb, and marked by a vertical groove, which indicates that both the first and second of the Sylvian gyri of the Dog are represented behind the Sylvian fissure, while only one of these canine gyri is represented in front of it. As in the Civet and Genet, the hinder part of the parietal gyrus is short, blending posteriorly and inferiorly with the sagittal gyrus behind the hinder end of the shortened

* See Leuret, *l. c.* p. 381; P. Gervais, p. 128, plate vii. fig. 5. See also P. Z. S. 1882, pp. 515 & 516, fig. 11; Krueg, *l. c.* plate xxxvi.

† As to its peculiarities, see P. Z. S. 1882, p. 169.

‡ See P. Gervais, *l. c.* p. 129, plate ix. figs. 2, 2 *a*, 2 *b*, & 2 *c*; and Krueg, *l. c.* plate xxxvi.

sulcus between them. The crucial sulcus is altogether absent from the cerebral surface; nevertheless the calloso-marginal sulcus is continued forward to the place where the crucial sulcus exists in most Carnivora, thus separating the hippocampal and sagittal gyri behind that point. The brain of *Hemigalea* agrees with that of *Paradoxurus*.

Arctictis.—The Binturong * has a brain similar to that of *Paradoxurus*, save that the sagittal and parietal gyri are separated posteriorly for a longer space, that the crucial sulcus is distinct though small, and that the sagittal gyrus is complicated by certain additional depressions.

Cynogale.—The brain of this animal is only known to me by Professor P. Gervais's figure of the cast of the inside of its skull †, which shows the cranial convolutions with exceptional distinctness. There is no crucial sulcus. The parietal sulcus, like that of every carnivorous animal not of the Dog group, does not bifurcate posteriorly. The hinder limb of the Sylvian gyrus shows no indication of subdivision, and the Sylvian fissure is described as "*longue et oblique en arrière*." The most marked peculiarity of this brain is the great expansion of the parietal gyrus at its anterior end, this expanded part being longitudinally grooved with short secondary grooves radiating from the longitudinal one.

Eupleres.—This very exceptional and insectivorous-like Carnivore ‡ is unfortunately, so far as I know, undescribed, save as regards the cast of the interior of the skull §. It appears to have the Sylvian gyrus formed as in *Paradoxurus*. There is no crucial sulcus visible, and the parietal gyrus does not bifurcate posteriorly. The most striking character shown by the figure of this cast is the very great breadth of the sagittal gyrus.

Herpestes.—The Mongooses have been placed in a category by themselves, as regards their cerebral structure, by MM. Leuret and Gratiolet ‖, on account of the apparently anomalous complexity of structure presented by at least some forms of this extensive genus. There appear to be sometimes as many as five

* See P. Gervais, p. 129, and plate vii. fig. 13, which represents a cast of the inside of the skull. See also P. Z. S. 1882, p. 516; but see especially Garrod, P. Z. S. 1873, p. 201, where a view of the side of the brain is given.

† See *l. c.* p. 128, plate vii. fig. 8.

‡ For its peculiarities, see P. Z. S. 1882, p. 189.

§ See P. Gervais, *l. c.* p. 130, pl. vii. fig. 2.

‖ See *l. c.* p. 383.

circum-Sylvian convolutions, so that the Ichneumons seem to exceed even the Dogs in their wealth of convolutions. In fact, however, not only is there no really special resemblance between the brains of *Herpestes* and *Canis*, but the brain is less convoluted than might appear from what has been said; for all the convolutions are narrow, single, longitudinal, and tend to be imperfectly separate one from another, especially towards the hinder part of the cerebrum *.

In some species the Sylvian gyrus is more or less subdivided both in front and behind the Sylvian fissure, and in others the sagittal gyrus is divided by a more or less extensive longitudinal groove. Thus it is that there may appear to be three, four, or even five circum-Sylvian gyri. The parietal gyrus, however, is never posteriorly subdivided as in the Dogs. One very marked character which distinguishes the brain of *Herpestes* from the brains of *Nandinia*, *Paradoxurus*, *Arctictis*, *Cynogale*, and *Eupleres* is its large crucial sulcus, which is always plainly to be seen, often rather forwardly situated, on the dorsum of the cerebrum. Into this sulcus the calloso-marginal sulcus is continued forwards, separating the hippocampal and sagittal gyri, as they have always been separated in all the species we have yet considered, except the species of Felidæ.

Galidia.—The brain of this elegant little genus is a simplified Herpestine brain, there being † but three circum-Sylvian gyri with a very large and conspicuous crucial fissure. The hinder limb of the Sylvian gyrus is vertically grooved.

Crossarchus.—The brain in this genus bears a large crucial sulcus, into which the calloso-marginal sulcus is continued. The Sylvian gyrus has its hinder limb twice as broad as its anterior limb, and the former is furrowed by a longitudinal vertical groove.

Suricata.—The Suricate ‡ has a brain which is remarkable for the great size of that part of the Sylvian gyrus which is posterior to the Sylvian fissure. This fissure has the appearance of being prolonged upwards, and then suddenly and much curved backwards and downwards, causing that part of the Sylvian gyrus

* See P. Gervais, *l. c.* p. 132, and plates vi. fig. 10, vii. fig. 4, viii. figs. 6 & 7, and ix. fig. 1. See also Krueg, *l. c.* plate xxxvi.

† See P. Gervais, p. 131, pl. vii. fig. 3.

‡ See P. Gervais, *l. c.* p. 133, pl. viii. figs. 5 and 5*a*; see also Krueg, *l. c.* pl. xxxvi.

which morphologically is behind the fissure to be actually in front of its distal portion. Behind this apparently recurved end of the fissure, there is a vertical groove on the middle of the Sylvian gyrus, which is thus altogether extremely broad posteriorly. The sagittal gyrus is longitudinally grooved at its hinder part, and there is a relatively large crucial sulcus, into which, no doubt, the calloso-marginal sulcus is duly continued.

Hyæna and Crocuta.—The brain of the Hyænas* shows a rather prolonged Sylvian fissure, while the posterior limb of the Sylvian gyrus is twice the breadth of its anterior limb, and is vertically grooved, and may be doubly grooved, so that the Sylvian fissure may seem to be posteriorly recurved. There is a very large crucial sulcus, into which the calloso-marginal sulcus is prolonged on the inner face of each hemisphere. The parietal shows no tendency to the canine bifurcation.

Proteles.—The brain of this singular animal † presents all the essential characters of that of the Hyænas.

Cryptoprocta.—I am indebted to the kindness of Professor Alphonse Milne-Edwards for a sketch of the brain of this animal, which is only otherwise known by a cast of the interior of its skull ‡. The crucial sulcus is distinct, though rather small, and anteriorly situated. The parietal and sagittal gyri communicate towards the hinder end of the cerebrum. The Sylvian gyrus appears to resemble rather that of the Hyænas, its posterior limb being double the width of its anterior limb, and obliquely grooved from above downwards. This groove, however, seems, by the drawing, to join above the upper part of the Sylvian fissure, which has thus an appearance of being recurved, as it has in the Suricate. It may be, however, that the Sylvian gyrus is very short and embraced by two distinct Sylvian gyri, as it is in the Dogs. If this is not the case, then the Sylvian gyrus is like that of *Herpestes*, *Crossarchus*, *Suricata*, and the Hyænas; while the connection between the parietal and sagittal gyri is a character which reminds us of the Felidæ. There is certainly no special resemblance to the *Viverrinæ*.

The non-canine and non-feline forms hitherto reviewed appear to present the following affinities:—In the first place their brain differs from that of the Cats by the non-continuance of the

* See Leuret, *l. c.* p. 378; and P. Gervais, *l. c.* p. 119, pl. ix. fig. 11 (brain of *Crocuta*); see also Krueg, *l. c.* pl. xxxvi., and Burt Wilder, *l. c.* fig. 9.

† See Flower, P. Z. S. 1869, pp. 478–482, figs. 1–4; and Krueg, *l. c.* pl. xxxvi.

‡ See P. Gervais, *l. c.* p. 123, pl. vi. fig. 2.

hippocampal into the sagittal gyrus behind the place of the crucial sulcus. Secondly, they differ from the Dogs in the non-bifurcation posteriorly of the parietal gyrus. Thirdly, they all agree together with both the Canidæ and Felidæ in not having any complication of the crucial sulcus by the extension of subordinate sulci forwards and inwards in front of its anterior margin.

The non-canine and non-feline species here considered—all of which belong to the non-feline portion of the suborder Æluroidea—divide themselves, as regards their cerebral structure, into two marked groups. To one of these belong the genera *Viverra*, *Genetta*, *Nandinia*, *Paradoxurus*, *Arctictis*, *Cynogale*, and *Eupleres**, which all (so far as I have been able to observe) differ from other Carnivora by the abortion, or quite rudimentary condition, of the crucial sulcus. Contrasted with these are the Æluroid genera *Herpestes*, *Galidia*, *Crossarchus*, *Suricata*, *Hyæna*, *Crocuta*, *Proteles*, and *Cryptoprocta*, all of which agree in having a well-developed crucial sulcus and a Sylvian gyrus, the hinder limb of which is twice or more (except sometimes in *Herpestes*) the breadth of its anterior limb, and bears a vertical groove.

We come now to the series of forms which constitute the Arctoid group of the Carnivora.

Procyon.—The brain of the Raccoon †, like that of all the forms which have hereinafter to be noticed, has three circum-Sylvian gyri, whereof the parietal gyrus does not bifurcate posteriorly, thus differing from the Canidæ. The Sylvian gyrus has its anterior limb much smaller than its posterior limb. The parietal gyrus is large, expanding anteriorly, becoming considerably contorted, and sometimes communicating, by a bridge of convolution, with the sagittal gyrus. The sagittal gyrus is very large, and becomes complicated anteriorly. This I find to be especially the

* Thus the cerebral structure justifies the affinities and classification of the Æluroids which I indicated in my paper on that group (in the Proc. Zool. Soc. 1882, p. 135), except as regards *Eupleres*, which I associated rather with the Ichneumons than with the Civets. It is interesting to note the evidence afforded by the brain of the affinity between the Hyænas and the Ichneumons. Professor Flower had already remarked (P. Z. S. 1869, p. 482, note §) the greater resemblance of the brain of the Suricate to that of the Hyænas than to that of the Civets.

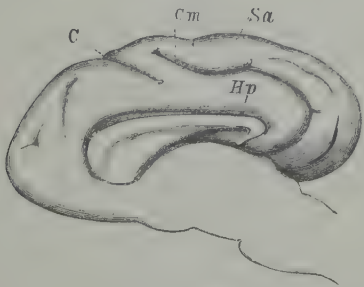
† See P. Gervais, *l. c.* p. 141, pl. viii. fig. 1; Krueg, *l. c.* pl. xxxvii. p. 633; and Burt Wilder, *l. c.* pl. ii. fig 11.

case in the brain of *P. cancrivorus*, where there are two or three bridging convolutions, on each side, between the parietal and sagittal gyri. In *Procyon* we find once more what we have found hitherto only in the Felidæ, namely, a continuation of the hippocampal gyrus upwards into the sagittal gyrus, behind the crucial sulcus, the calloso-marginal sulcus not being continued forwards with the latter. The crucial sulcus is very large and distinct, and presents a character which I have not found to exist in the brain of any non-Arctoid Carnivore. From the anterior margin of the crucial sulcus of either hemisphere a secondary sulcus diverges forwards and inwards, and thus the proximal parts of the two halves of the great crucial sulcus, together with the secondary and anteriorly approximating sulci, form altogether a lozenge-shaped patch of brain-substance which is sufficiently conspicuous.

The Sylvian fissure is very elongate and very oblique.

Nasua.—The brain of the Coati * is mainly like that of the Raccoon; but the part in front of the large crucial sulcus is relatively more extensive, and the sagittal gyrus is larger and more complicated with grooves and depressions. One great difference, however, between the two brains is the small size in *Nasua* of the

Fig. 1.



Vertical median section of cerebrum of *Nasua rufa*, nat. size.
C. Crucial sulcus. *Cm.* Calloso-marginal sulcus. *Hp.* Hippocampal gyrus. *Sa.* Sagittal gyrus.

lozenge-shaped patch of brain-substance in front of the crucial sulcus. The fact that minute secondary sulci do converge forwards from the crucial sulcus, I have been careful to verify by a special examination of a brain freshly extracted for the purpose.

* See Leuret, *l. c.* p. 381, pl. vi.; and P. Gervais, *l. c.* p. 140, pl. ix. fig. 10; also Krueg, *l. c.* pl. xxxvii.

They are, however, very minute, and more or less hidden under the fold of cerebrum which overhangs the crucial sulcus posteriorly. I have also ascertained that the calloso-marginal sulcus does not attain the crucial sulcus, so that the hippocampal and sagittal gyri join below the former sulcus.

Ailurus.—The brain of the Panda * is well represented in the Museum of the Royal College of Surgeons. The anterior limb of the Sylvian gyrus is but little wider than its posterior limb. The latter is marked by a secondary sulcus, which descends from the hinder margin of the elongated Sylvian fissure, producing the appearance of a recurvation of that fissure—an appearance already noted in the brain of *Suricata* and *Hyæna.* In other respects the cerebrum much resembles that of *Procyon*, save that there is a feebler indication of the lozenge-shaped patch of brain-substance in front of the large crucial sulcus. Behind that sulcus, the hippocampal gyrus joins with the sagittal one, as in *Procyon* and *Nasua.*

Ailuropus.—I have not seen the brain of this very interesting form, but only a mould of the interior of the skull †. The brain is evidently short and broad, with a very large crucial sulcus, which gives off in either hemisphere a secondary sulcus proceeding inwards and forwards, and so defining a large and conspicuous lozenge-shaped tract of brain-substance, which is larger (relatively as well as actually) in this somewhat bear-like animal than in the preceding Arctoid species. I shall henceforth speak of this cerebral patch as the "*Ursine lozenge.*" The Sylvian fissure is very long and placed very obliquely. The Sylvian gyrus has its anterior limb much the narrower. The anterior limb of the sagittal gyrus is very large and very much convoluted.

Bassaris.—The cranial characters of this much-disputed genus have already abundantly proved that it is no Viverrine animal, but belongs to the great Arctoid group. (Prof. P. Gervais's figure of a cast ‡ of the interior of the skull is the least satisfactory and instructive of his whole series.) Nevertheless, the existence of a large crucial sulcus would alone be a strong argument against its having an affinity to the Civets. It seems

* This is noticed by P. Gervais, *l. c.* p. 141, and he figures (pl. viii. fig. 8) a mould of the inside of the skull. The brain itself is described and figured by Professor Flower, Proc. Zool. Soc. 1870, pp. 755–757, figs. 1, 2, & 3.

† See P. Gervais, *l. c.* p. 136, pl. viii. fig. 9.

‡ See *l. c.* pl. vii. fig. 6; for a notice see p. 140.

generally, as might be expected, to show a resemblance to the brains of *Procyon* and *Nasua*, though it is less convoluted. It shows a long Sylvian fissure embraced by a simple Sylvian gyrus.

By the kindness of Professor Flower and Dr. Günther I have been enabled myself to obtain a cast of the interior of the skull of this animal, which cast I have deposited in the British Museum, South Kensington. Unfortunately it shows but little of the convolutions, but the size and forward position of the crucial sulcus agree with Gervais's figure. There is no positive indication, that I can perceive, of an "Ursine lozenge," though there is no evidence against its presence, the part being indistinct. The sagittal gyrus is exceedingly wide, and complicated by a median longitudinal groove.

Bassaricyon.—It is again through the kindness of Professor Flower and Dr. Günther that I am enabled to contribute any notes as to the cerebral form of this species. It is as yet entirely unknown; but I have been allowed to take a cast from the interior of the skull, which cast I have also presented to the British Museum. By it, it seems that there is a very large crucial sulcus, not placed so far forwards as in *Bassaris*. On one side there is a distinct indication of the presence of an "Ursine lozenge." The sagittal gyrus seems to be very broad, but the indications are unfortunately very indistinct. There is an appearance which seems to show that the anterior limb of the Sylvian gyrus is narrower than its posterior limb.

Cercoleptes.—The brain of the Kinkajou * is short and somewhat rounded. Its sagittal gyrus is very wide, and tends to subdivide longitudinally. The parietal gyrus broadens out much anteriorly. The Sylvian fissure is long and oblique, and its embracing Sylvian gyrus has its anterior limb a little narrower than its posterior limb. Professor Gervais says that he found no "plis de passage;" but I find a bridging convolution anteriorly, on each side, between the parietal and sagittal gyri. The crucial sulcus is very large, and sends inwards, on either side, a rather faintly marked secondary sulcus, by which a large "Ursine lozenge" is distinctly, though not strongly, defined. The crucial sulcus is joined by the anterior end of the calloso-marginal sulcus, thus cutting off the hippocampal gyrus from the sagittal one †.

* See P. Gervais, *l. c.* p. 141, pl. ix. fig. 3; and Krueg *l. c.* pl. xxxvii.

† See Leuret, *l. c.* p. 381; and P. Gervais, p. 144, pl. ix. fig. 6.

Meles *.—I find that the Sylvian gyrus has its anterior limb the narrower, and the parietal gyrus single both in front and behind. The sagittal gyrus, on the contrary, expands very much forwards and is very contorted, and has certain superficial linear depressions on its more posterior part. The anterior part of the cerebrum is very largely developed, the crucial sulcus being placed very far back. A small, but very distinct, secondary sulcus extends forwards and inwards in either hemisphere from very near the middle line of the crucial sulcus. Thus a very small Ursine lozenge is formed, but one which is at the same time very definite and distinct. I have had no opportunity of ascertaining whether the calloso-marginal sulcus is continued forwards on to the crucial sulcus, but it is represented as so doing by Krueg.

Mellivora.—The brain of the Ratel is referred to by Professor

Fig. 2.

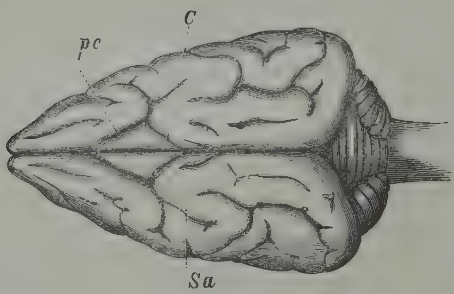


Fig. 3.

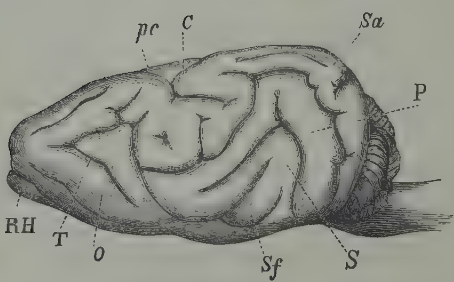


Fig. 2. Dorsal surface of brain of *Mellivora indica*, natural size. *C.* Crucial sulcus. *pc.* Precrucial sulcus. *Sa.* Sagittal gyrus.

Fig. 3. Right side of brain of *Mellivora indica*, natural size. *C.* Crucial sulcus. *O.* Orbital gyrus. *P.* Parietal gyrus. *pc.* Precrucial sulcus. *RH.* Rhinencephalon. *S.* Sylvian gyrus. *Sf.* Sylvian fissure. *Sa.* Sagittal gyrus. *T.* T-shaped sulcus.

* See Krueg, *l. c.* pl. xxxvii.

P. Gervais *, but is neither described nor figured by him, nor do I know of any published representation of it. The Sylvian fissure is long and oblique. The Sylvian gyrus is very much broader posteriorly, the anterior limb being exceedingly narrow. The parietal gyrus is quite simple, and its anterior and posterior limbs are about equal. The sagittal gyrus is enormously expanded anteriorly. Its most posterior part is quite simple and single, but behind the crucial sulcus it is longitudinally grooved. It then doubles backwards and afterwards curves forwards in complex convolutions, surrounding the crucial sulcus. The latter, which is well developed, sends forwards secondary sulci, and so forms a rather elongated "Ursine lozenge."

The supraorbital gyrus (fig. 3, *O*) is large, and bears a T-shaped or Y-shaped vertical sulcus (*T*).

The calloso-marginal sulcus does not join the crucial one, but a very narrow bridging convolution connects the hippocampal and sagittal gyri behind the crucial sulcus.

Galictis †.—In the Tayra, the part of the cerebrum which is anterior to the crucial sulcus is smaller than in *Mellivora*. The upper surface of the brain is singularly complicated by supplementary depressions, and by bridging convolutions which connect the parietal and sagittal gyri, so that it is very difficult to determine which gyrus of the two is the one which is the more broadened and complicated anteriorly. Indeed, it seems impossible to draw any well-defined boundary between them. The Sylvian fissure is oblique and prolonged. The Sylvian gyrus is simple, and has its anterior limb very decidedly the narrower. The parietal gyrus, if it could be considered simple, must be said to blend with the sagittal gyrus by several bridging convolutions. The sagittal gyrus must then be considered as very wide, and as bearing two longitudinal grooves at its middle part. It blends, as just stated, with the parietal sulcus, and expands widely as it advances forwards. Its hindmost part is very broad, and bears a median longitudinal groove. The crucial sulcus sends forwards, on either side, a groove to define a small "Ursine lozenge." It is not joined by the calloso-marginal sulcus, a bridging convolution connecting the hippocampal and sagittal gyri behind the crucial sulcus.

* See *l. c.* p. 145.

† Referred to by P. Gervais, *l. c.* p. 144. He gives no figure.

Fig. 4.

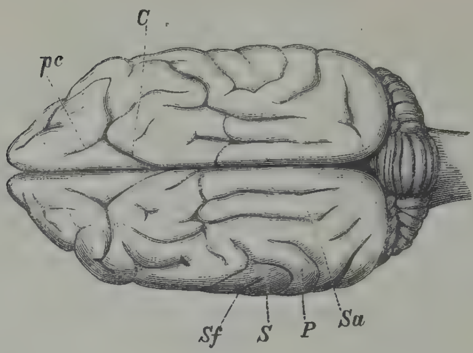


Fig. 5.

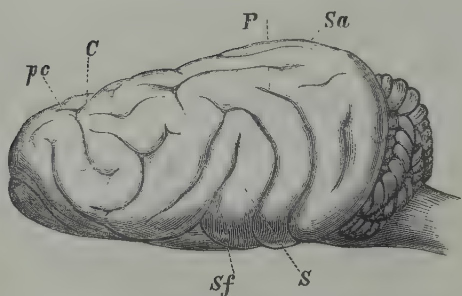


Fig. 4. Dorsal surface of brain of *Galictis*, natural size. *C.* Crucial sulcus. *P.* Parietal gyrus. *pc.* Precrucial sulcus. *S.* Sylvian gyrus. *Sa.* Sagittal gyrus. *Sf.* Sylvian fissure.

Fig. 5. Lateral view of brain of *Galictis*, natural size. *C.* Crucial sulcus. *P.* Parietal gyrus. *pc.* Precrucial sulcus. *S.* Sylvian gyrus. *Sa.* Sagittal gyrus. *Sf.* Sylvian fissure.

Grisonia *.—The brain of the Grison is so different from that of the Tayra (*Galictis*) as to constitute an argument of some weight in favour of the distinctness of the two genera. In that of the Grison, the hippocampal gyrus is cut off from the sagittal gyrus by the junction of the calloso-marginal and crucial sulci. There is also a much larger proportional part of cerebrum in front of the crucial sulcus in *Grisonia* than is the case in *Galictis*. The sagittal gyrus is very wide, and blends anteriorly with the parietal gyrus. The Sylvian gyrus is oblique and rather short.

The crucial sulcus is well developed, and an " Ursine lozenge " is more or less distinctly defined in front of it.

* Or *Galictis vittata*.

Fig. 6.

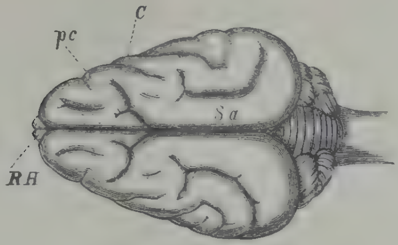


Fig. 7.

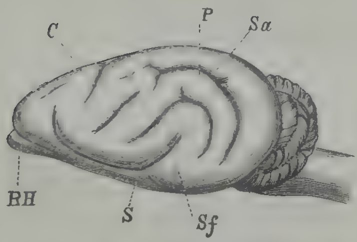


Fig. 6. Dorsal surface of brain of *Grisonia*, natural size. *C.* Crucial sulcus. *RH.* Rhinencephalon. *pc.* Precrucial sulcus. *Sa.* Sagittal gyrus.

Fig. 7. Lateral view of brain of *Grisonia*, natural size. *C.* Crucial sulcus. *P.* Parietal gyrus. *RH.* Rhinencephalon. *S.* Sylvian gyrus. *Sa.* Sagittal gyrus. *Sf.* Sylvian fissure.

Gulo.—The brain of this animal is only known to me through the description and figure of the cast of the inside of its skull given by Professor Gervais *. He says :—" Je n'y retrouve pas, du moins sur le moule intra-cranium, le dédoublement des deux circonvolutions supérieurs caractéristiques du *Galictis barbara*."

The cast shows signs of the presence of an " Ursine lozenge," which seems to be much elongated antero-posteriorly ; also of a greatly expanded and convoluted anterior limb to the sagittal gyrus, as well as of a longitudinal grooving of its middle and hinder part. I can say nothing, of course, as to the inter-relations between the hippocampal and sagittal gyri.

Mustela.—The Martens and Weasels † have that more simple

* See *l. c.* p. 145, pl. vi. fig. 7.

† See Leuret, *l. c.* p. 381, pl. vi. ; and P. Gervais, p. 143, pl. vi. fig. 3 (intercranial cast) ; see also Krueg, *l. c.* pl. xxxvi.

condition of brain-surface which characterizes the smaller forms of each group of Mammals. Nevertheless, the three circum-Sylvian gyri are all distinctly present, though, as has been remarked by Professor Flower *, the sulcus separating the sagittal and parietal gyri is less produced posteriorly in them than it is in other species of Carnivora. They have, however, a long and oblique Sylvian fissure. The Sylvian gyrus seems generally to have its posterior limb the narrower. The parietal sulcus does not communicate with the sagittal, save at the ends of the, posteriorly short, sulcus which divides them. The sagittal gyrus is much the widest of the three circum-Sylvian gyri. There is a considerable crucial sulcus which is placed rather far back. In front of it there is either an unmistakable "Ursine lozenge," or a distinct trace of it. The crucial and calloso-marginal sulci unite.

Ictonyx.—The brain of the Zorilla has been well figured by Professor P. Gervais †. Its Sylvian fissure is long and oblique. The Sylvian gyrus is much narrower in front than it is behind the Sylvian fissure. The parietal gyrus is simple. The sagittal gyrus is wide, especially towards its anterior end. The crucial sulcus is large, and placed rather far back, a considerable, or moderate, part of the cerebrum lying in front of it. There is a distinct, but small, "Ursine lozenge;" and the hippocampal gyrus is divided from the sagittal by the junction of the calloso-marginal and crucial sulci. The sulcus which divides the parietal and sagittal gyri does not extend far backwards in this genus any more than in *Mustela*, ceasing near the posterior superior angle of the cerebrum.

Helictis.—The brain of this animal has been described and figured by the late Professor Garrod ‡. The anterior limb of the Sylvian gyrus is much the narrower; the parietal and sagittal gyri unite at the posterior superior angle of the cerebrum, as in *Ictonyx*. The calloso-marginal and crucial sulci unite and separate the hippocampal and sagittal gyri. There is a very distinct "Ursine lozenge," but it is open behind owing to the non-junction medially of the two halves of the crucial sulcus, each hippocampal gyrus rising to the surface in a most excep-

* P. Z. S. 1869, p. 482, note ‡.

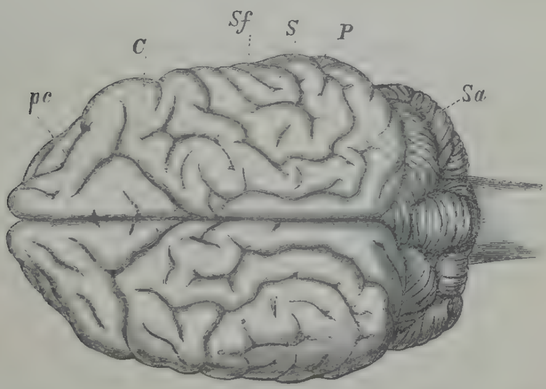
† See *l. c.* pl. ix. fig. 4; for a notice, see p. 144.

‡ See Proc. Zool. Soc. 1879, p. 307, figs. 1 & 2.

tional manner, and forming, on each side, the boundary of the median longitudinal fissure of the cerebrum.

Ursus.—The Bear's brain has been carefully described and admirably figured by MM. Leuret and Gratiolet*. I have examined the brains of nearly all the species, including that of the Sloth-Bear (*Melursus*). In all, the Sylvian sulcus has its anterior limb very much narrower than its posterior limb; in all, the parietal gyrus is simple and single; in all, the sagittal gyrus is very complex, and tends to become longitudinally divided into two; it is greatly expanded and much convoluted anteriorly. In all the

Fig. 8.



Dorsal surface of brain of *Ursus maritimus*, half natural size.
C. Crucial sulcus. *P.* Parietal gyrus. *pc.* Precrucial sulcus. *S.* Sylvian gyrus. *Sa.* Sagittal gyrus. *Sf.* Sylvian fissure.

species, the Sylvian fissure is exceedingly long and very oblique; and in all the hippocampal gyrus joins the sagittal gyrus, a bridging convolution dividing the crucial and calloso-marginal sulci. Finally, in the Bears we find present a large and very marked "Ursine lozenge," which in them attains its maximum of distinctness. It may be formed in different ways, either by secondary sulci proceeding forwards from the crucial sulcus, or by such sulci independently placed in front of it; and the condition may vary on the two sides of the same brain.

* See *l. c.* p. 375, pl. vi.; and P. Gervais, *l. c.* p. 134, pl. viii. fig. 10 (cast), and pl. ix. fig. 9 (brain itself); also Krueg, *l. c.* p. 635 and pl. xxxvii.; and Burt Wilder, *l. c.* fig. 10.

Lutra.—Three good figures of the brain of the Otter are given by Leuret and Gratiolet *, and it is also described and figured by Professor P. Gervais † and by Krueg ‡. These authors describe and represent the parietal sulcus as greatly broadening out anteriorly, and becoming connected by a "plis de passage" with the sagittal gyrus. In the specimens I have examined it seems, on the other hand, to be rather the sagittal which is enormously expanded towards its anterior end. The crucial sulcus is placed far back, but shows in front of it an unmistakable, though faintly marked, "Ursine lozenge." As in *Ursus* and certain other forms already mentioned, the anterior limb of the Sylvian gyrus is very much narrower than its posterior limb. The Sylvian fissure is very long, and extremely oblique in position. The hippocampal gyrus (according to Krueg) is separated from the sagittal by the junction of the crucial and callosomarginal sulci.

MM. Leuret and Gratiolet justly remark upon the possible deception which may arise as to the cerebral condition of an animal from an inspection of its skull only. The cranium of *Lutra* would seem to show that it is the hinder part of the brain which is specially enlarged, whereas the fact is that it is the anterior part of the brain which is relatively so augmented in volume.

Enhydra.—A cast of the interior of the skull of the Sea-Otter is figured and described by Professor P. Gervais §. It differs much from that of *Lutra* in that the crucial sulcus is placed more forwards, and the "Ursine lozenge" is much more conspicuous and relatively larger. The cerebrum seems to be very convoluted, the parietal gyrus expanding much anteriorly, and the middle of the sagittal gyrus being longitudinally grooved.

Thus the Arctoid Carnivora present us with cerebral characters by which they may be distinguished from the Canidæ (or Cynoidea) on the one hand, and from the Æluroidea on the other.

They differ from the first in not having four circum-Sylvian gyri, in not having the Sylvian gyrus subdivided, and in not having the posterior limb of the parietal gyrus bifurcating.

* See *l. c.* p. 382, pl. vi.

† *L. c.* p. 146, pl. ix. fig. 8.

‡ *L. c.* p. 631, pl. xxxvii.

§ See *l. c.* p. 146, pl. vi. fig. 9.

They also almost all differ from the Cynoidea by having generally a junction between the hippocampal and sagittal gyri, and, almost universally, by the possession of a precrucial "Ursine lozenge."

They also differ from the Æluroidea in that they have the "Ursine lozenge"; in that the anterior limb of the Sylvian gyrus tends to be, and very often is, much more slender than its posterior limb. They also differ from all non-feline Æluroids by mostly having a junction of the hippocampal and sagittal gyri behind the crucial sulcus. The Arctoids also differ from all other Carnivora by their tendency to a greater development in breadth and complexity of the sagittal gyrus.

The Pinnipedia.

The cerebrum of the Seals *, as is well known, is very different in aspect from any of the brains of the true Carnivora, whether the latter are purely terrestrial or more or less aquatic in their habits. It is generally more rounded in form and more richly convoluted, while the circum-Sylvian gyri are less distinct and easily defined, the parietal and sagittal sulci especially blending; moreover the crucial sulcus does not appear, when the brain is placed beside that of the true Carnivora.

Cystophora.—The brain of this genus is well represented in the collection of the Royal College of Surgeons. It shows a Sylvian fissure of moderate extent and somewhat vertical in position. The Sylvian gyrus is very complex and contorted, and joins the parietal gyrus by bridging convolutions, which are not constant in position. The latter gyrus ends abruptly a considerable distance behind the anterior end of the sagittal gyrus, which attains the front edge of the cerebral hemisphere and, as usual, surrounds the crucial sulcus. This latter sulcus is invisible, or all but invisible, when the dorsum of the cerebrum is looked at, owing to its being placed much further forwards than in any of the true Carnivora, namely quite at the anterior end of the cerebrum.

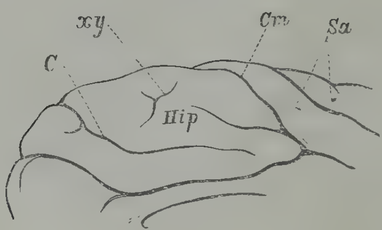
Phoca †.—In the brain of a Common Seal, which I had extracted for this paper, I found some very interesting conditions. Generally, the convolutions were like those of the form last noticed, and though a crucial sulcus could be detected at

* See Leuret, *l. c.* p. 390, pl. xi.; and Krueg, p. 642, and pl. xxxviii.

† See Leuret, p. 390, pl. xi.

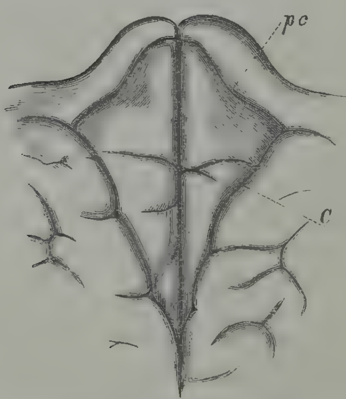
the anterior end of the cerebrum, there seemed at first to be no indication of an Ursine lozenge. By slightly separating

Fig. 9.



Vertical median section of part of the brain of *Phoca vitulina*, natural size. *C.* Crucial sulcus. *Cm.* Calloso-marginal sulcus. *Hip.* Hippocampal gyrus. *Sa.* Sagittal gyrus. *xy.* Secondary sulci.

Fig. 10.



Dorsal surface of anterior median part of brain of *Otaria Gillespii*, natural size.
C. Crucial sulcus. *pc.* Precrucial sulcus.

the cerebral folds, however, a small secondary, forwardly and inwardly proceeding sulcus could be detected on each side, so that a minute "Ursine lozenge" might be made out when the brain was viewed anteriorly.

A vertical section of the brain shows that the calloso-marginal sulcus is very widely separated from the inward prolongation of

the crucial sulcus, the very wide and voluminous hippocampal gyrus (grooved by secondary sulci *xy*) rising to the surface behind the crucial sulcus (fig. 9). The fold of cerebral substance thus interposed is far larger than any met with in even the Arctoid terrestrial Carnivora.

Otaria.—The brain of the Sea-Bear * is very instructive, for it supplies what would otherwise be a "missing link" of much importance between the brain of the Seals and that of the ordinary land Carnivora. In the first place it is intermediate in general form. It is less rounded than in the Seals, but differs from that of the ordinary Carnivora by being about as broad in front as it is behind. The Sylvian fissure is long (as in the Bears), but more vertical. The three circum-Sylvian gyri are much blended, and the whole cerebrum much convoluted. The parietal and sagittal gyri are very complex and extensively blended by bridging convolutions; they expand much anteriorly, and surround a very distinct crucial sulcus, which is here placed on the dorsum of the cerebrum (fig. 10). Moreover this crucial sulcus sends forwards converging secondary sulci which produce a very marked and unmistakable "Ursine lozenge" near the anterior end of the cere-

Fig. 11.

Median vertical section of part of brain of *Otaria Gillespii*, half natural size.

C. Crucial sulcus. *Cm.* Calloso-marginal sulcus. *Hip.* Hippocampal gyrus. *Sa.* Sagittal gyrus. *x* & *y*. Secondary sulci.

brum. The Ursine lozenge is distinct and large, and the crucial sulcus is very conspicuous. But for the distinctness of this lozenge in *Otaria*, I should probably have failed to detect the minute and obscure lozenge of *Phoca*; and thus the brain of *Otaria* is truly a link which it would have been unfortunate to

* This has been described and figured by Dr. Murie, F.L.S. See Trans. Zool. Soc. vol. xiii. pp. 519–527, pl. 78 & pl. 79. fig. 44.

miss. The calloso-marginal and crucial sulci are widely separated by a large hippocampal gyrus, which rises to the surface of the cerebrum (fig. 11). Nevertheless there is a deceptive appearance of junction between the crucial and calloso-marginal sulci by the uprising of an oblique secondary sulcus (y), which ascends from the hinder part of the backward prolongation of the crucial sulcus almost to that part of the calloso-marginal sulcus which joins the dorsal surface of the cerebrum.

Thus the cerebral characters of the Carnivora and Pinnipedia fully justify and confirm the inductions so long ago made by the late Mr. H. N. Turner *, and further worked out and improved by Professor Flower †. The cerebra of these animals group themselves, I think, unmistakably in four sets corresponding with the *Arctoidea*, the *Æluroidea*, the *Cynoidea*, and the *Pinnipedia*, though the brains of the *Viverrinæ* are so divergent through the atrophy of the crucial sulcus, that they may be held to constitute a fifth subordinate group by themselves. Do the facts here given throw any, and, if any, what, glimmering of light on genetic affinity and Phyllogeny?

The late Professor Garrod threw out the suggestion ‡ that the brain of the Dogs was a further and higher development of that of the Viverrine group, passing upwards through the Felidæ.

I cannot, however, any more than Professor Flower § or Professor Huxley, favour such a genealogical table of the Carnivora, on account of other, non-cerebral, anatomical considerations; but though I cannot regard this sketch of Professor Garrod's as happy phylogenetically, it appears to me to be a very correct one morphologically, and that his words express fairly well the morphological relations between the cerebra of the different groups of Carnivorous Mammalia.

There is a point, however, as to which the Carnivorous brain does appear to me to afford a solid ground for accepting a certain phylogenetic view. The Pinnipedia form a group so peculiar as to make their origin a question of some difficulty. The brain of the Seals is so divergent from that of the ordinary Carnivora, that MM. Leuret and Gratiolet separated it widely from the latter, relegating it ‖ to their eleventh mammalian group, and interposing the whole of the Ungulates and Edentates between

* P. Z. S. 1848, p. 86.

† P. Z. S. 1869, p. 85.

‡ See P. Z. S. 1878, p. 377.

§ See P. Z. S. 1880, pp. 75 & 76.

‖ See *l. c.* p. 371.

that eleventh group and their group of Carnivora. It has been often suggested that the Bears are the nearest existing allies of the Seals. There is, however, little in the anatomy of the true Seals to force conviction on us as to this matter; but when we turn to the brain of *Otaria*, we may, I think, therein read a very striking confirmation of the suggestion. The Arctoid group, and the Arctoid group alone of all Carnivora, possesses an "Ursine lozenge." That striking and exceptional feature is plainly to be seen (as herein pointed out) in the brain of *Otaria*. This circumstance, I venture to think, makes it very highly probable that the ancestor of the Pinnipedia was an Arctoid animal not very remote from the Ursine group of that extensive suborder.

In conclusion I desire to express my thanks to the authorities of the Royal College of Surgeons for the great facilities afforded me in studying the subject, and for their kindness in permitting drawings to be made from the specimens therein preserved.

On the Family *Arbaciadæ*, Gray.—Part I. The Morphology of the Test in the Genera *Cœlopleurus* and *Arbacia*. By P. Martin Duncan, F.R.S., V.P.L.S., and W. Percy Sladen, F.L.S.

[Read 5th February, 1885.]

(Plates I. & II.)

Contents.

I. *Introduction.*

The Arbaciadæ of Gray, or the Echinocidaridæ of Desmoulins, have been studied, more or less, by nearly every naturalist who has investigated or classified the Echinoidea.

The embryology of species of the genus which gives the name to the family has been studied by A. Agassiz, Selenka, Busch,

Fewkes, Garman, and Colton; and every one of us who is interested in the subject, will remember that a species was traced during the stages of its early growth, from the Pluteus to the young perfect form, by Johannes Müller, the father of this kind of research, in 1855.

The classificatory studies of the family, the descriptions of the species, and the arguments regarding the affinities of the forms, and the necessary limitation of the family to certain genera, have occupied the attention of especially Desmoulins, Gray, Desor, E. Forbes, Blainville, L. Agassiz, Aradas, Sars, Delle Chiaje, Verrill, A. Agassiz, Lütken, and Troschel. We owe some important morphological studies to Lovén, and also to A. Agassiz and Troschel.

The 'Revision of the Echini' by A. Agassiz contains, besides the synonymy of the species of the genera of the family, the history of the successive writings on the group, and the arguments regarding the propriety of extending the family so as to include the genera *Cœlopleurus* and *Podocidaris*, and also very careful descriptions and drawings of the more important parts of the species.

The value of these researches by A. Agassiz is enhanced by his subsequent writings in the Report on the Echinoidea of the 'Challenger' Expedition, and in his Report on the dredgings of the U. S. Steamer 'Blake.' The delineations of *Arbacia nigra* (Molina, sp.) by Lovén in his 'Études sur les Échinoïdées,' and those of the species of *Arbacia*, *Cœlopleurus*, and *Podocidaris* by A. Agassiz, leave little to be desired.

In 1883 we were describing the Tertiary Echinoidea of Kachh and Kattywar for the 'Palæontologia Indica,' and we had the opportunity of studying excellent specimens of species from two geological horizons, namely the Oligocene and Miocene. Subsequently we extended our work, and have completed the description of the Echinoidea of Sind.

We have thus been enabled to study several points in the morphology of the test of four species of *Cœlopleurus*; and the result led us to examine the recent species of *Cœlopleurus* from the seas to the east of Africa. Owing to the kindness of Dr. Günther, F.R.S., we have been enabled to examine the specimens of *Cœlopleurus Maillardi*, A. Agassiz, in the National Collection, and to compare their structures with those of the fossil forms.

Pursuing our investigations, we studied the test of the species

of *Arbacia* in the National Collection, with the assistance of some specimens belonging to us; and it has resulted that we can offer to those students of the Echinoidea who are interested in this family, some descriptions of new morphological details which must affect the classification.

The communication which we bring before the Society consists of two parts. In the first, the nature of the structures of the ambulacra, of the interradial plates, and of the radial plates in the fossil and recent *Cœlopleuri* and in the species of *Arbacia* are considered. In the second part we shall consider the classification of the family.

We use the name *Arbacia* because Gray, in our opinion, has the precedence over Desmoulins, whose name *Echinocidaris* is, however, much the better of the two.

Genus Cœlopleurus, *L. Agassiz.*

II. *The Fossil Species of* Cœlopleurus, *L. Ag.**

The Ambulacra.—The species which were examined were *C. equis*, Ag., *C. Pratti*, d'Archiac, *C. Forbesi*, d'Archiac, and *C. sindensis*, nobis †.

The ambulacra of the species of *Cœlopleurus* which are found fossil may, for the purpose of description, be divided into three regions—the region of the ambitus, that of the peristome, and the apical region. The arrangement of the plates differs in each of these divisions; but it is evident that in the fossil forms, as in the recent, the plates of the aboral region were the last formed, the peristomial are the oldest, and the plates of the ambitus are of an intermediate age. It is also evident that, in common with other Echinoidea with multiple or combined plates, the *Cœlopleuri* present the simplest plates in the aboral region of the ambulacra and the most complicated in the peristomial portions, but the complication is very slight there in the genus now under consideration.

All the fossil species of the genus *Cœlopleurus* from the Oligo-

* The literature of the Arbaciadæ is carefully given in the 'Revision of the Echini' by Alex. Agassiz, and we may add two references of work which relates to that we now describe:—Lovén, 'Études sur les Échinoïdées,' Stockholm, 1874; Troschel, Archiv für Naturgeschichte, Wiegmann, 1872, p. 293, and 1873, p. 308.

† "Fossil Echinoidea of Sind:" Nari and Gáj Series, 1884–1885; "Fossil Echinoidea of Kachh and Kattywar," 1883: see 'Palæontologia Indica,' Series XIV. (Duncan and Sladen).

cene and Miocene of Sind and Kachh are characterized by the great development of the ambulacra, their tumidity, the presence of great primary tubercles in them, decreasing in size towards the peristome and the apical region, and the presence of triple pairs of pores around the great tubercles.

The arrangement of the three plates which form a compound and tubercle-bearing plate, in so many genera, has been described in many works on the Echinoidea, and illustrated by almost every writer on the subject. Take, for example, a plate with three pairs of pores in the young form of a species of *Strongylocentrotus*, as drawn by Lovén * (Pl. I. fig. 1).

The plate is seen to be traversed by the imperfectly united sutural edges of three plates, of which the middle one is small and does not reach far into the united plate. The two others are large, and they both and their uniting suture reach the inner or median line of the ambulacrum.

The two large plates, a' & a'', are called primary, because they reach from the outer to the inner edge of the multiple plate, and thus are comparable with true primary plates which are separate, and reach from the interradium to the median line of the ambulacrum.

The small plate, *b*, which fits in between the two primaries close to the interradial edge of the compound plate is called a demi-plate. The junction of the edges of the large plates, beyond the inner angle of the little demi-plate, is long, simple, and directed inwards towards the inner margin of the multiple plate and also upwards.

This line of united suture-edges is oblique in its direction, and therefore one of the large or primary plates must be larger than the other. In the example of the young *Strongylocentrotus* it is, as is usual, the lower or adoral primary which is the largest, and because the direction of the upper edge of it is inwards and upwards. When there is a tubercle on the multiple plate, the line of the junction of the upper and lower primary plates crosses it.

The line may cross the boss, or the mamelon, or the space between the top of the boss and the mamelon, and usually the inner end of the demi-plate separates the long line of junction of the others, on the shoulder of the tubercle.

The study of the ambulacral plates close to the radial plate shows that, however complicated they may be lower down in the

* 'Études,' Plate xvii. fig. 140.

test, they are simple and primary when first produced, and that as there is a gradual growth of plates from the radial-plate end towards the peristome during the whole life of the individual, the increasing pressure from above downwards, or aborally adorally, produces absorption of, or interferes with the growth of, the inner parts of some plates and develops the demi-plate.

The demi-plate intercalated between the large primaries in a compound or multiple plate, is not an independent or super-added structure, but a modification of a primary plate during the growth of the ambulacrum as a whole.

Lovén has shown, in his 'Études,' pp. 23, 24, that even the apparently confused doubling and trebling of the arcs of the pairs of pores near the peristome in some adult Echini, is not due to the development of new pore-bearing plates, but to a downward movement and diminution of the height and breadth of the original plates accompanied by a movement of the pairs of pores, especially of those in the larger plates of the compound plates. There is no real confusion, for the pairs of pores assume their places in a regular order.

Cœlopleurus. Region of the Ambitus.—If a large tubercle-bearing plate of an ambulacrum of one of the species of *Cœlopleurus* already named be carefully examined, there is no difficulty in deciding that it is really a multiple or compound plate, and that the arrangement of the three plates which compose it is totally different from that as yet observed in any other genus. Before describing the three plates, it is necessary to remark that the tubercle has a large flat edge to its base, which comes so close to the poriferous zone that the inner pores of the pairs of the triplet intrude on it, and as it were slightly erode it. The tubercle is large, covers nearly all the rest of the plate, and slopes up to a circular groove which is at the narrow base of a mamelon which is very small in relation to the size of the boss beneath. In some instances the base of the tubercle is not thus intruded upon (Pl. I. fig. 3).

On examining the three plates of this compound and tubercle-bearing plate, it is found that there is only one primary (a), and on the other hand there are two demi-plates (b', b''). Moreover the upper or aboral plate and the lower or adoral plate of the compound plate are demi-plates, the large single primary being between them and extending far beyond them towards the inner edge of the plate at the median line.

The demi-plates are small and the primary is very large.

The demi-plates form a small part of the aboral and adoral mass of the boss, and the primary plate forms part of the outer or interradial side of the boss, the whole of the mamelon, and the whole of the inner half of the tubercle towards the median line of the ambulacrum (Pl. I. figs. 2 & 3).

The part of the tubercle-bearing plate between the mamelon and the median or vertical suture is free from any suture or sutures, and none cross it after the fashion of typical Triplechinidæ. The sutures of the demi-plates never come in contact, and therefore the inner part of the compound plate is not divided into two portions, and only one plate, the central of the triplet, reaches the line of the median suture of the ambulacrum.

The Aboral Demi-plate.—This is rather large for a demi-plate, and is about one third of the whole height of the compound plate in vertical measurement, that is to say near the interradial edge; further in, and on the shoulder of the boss of the tubercle, the height is about one sixth more. The breadth of the plate is about one half of that of the entire compound plate, but it may be a little more or less (Pl. I. figs. 2, 3). The edge of the demi-plate in contact with the interradium is low and curved, with the convexity outwards, and the opposite or inner edge is the longest in vertical measurement, and is situated upon the aboral slope of the boss. It there forms a rounded angle, usually rather acute in large tubercles. The angle is situated at the groove on the summit of the boss, and below the mamelon.

The direction and relative position of the edges or sutures of this plate are very singular. The adoral suture is entirely in contact with the abactinal edge of the outer or poriferous part of the large primary plate. This adoral suture commences at the interradial edge of its plate, and passes inwards and slightly adorally, to the adoral pore. Thence it is directed still slightly adorally and inwards up the tubercle towards the groove at the base of the mamelon; it then becomes curved, turns at an angle directly towards the apical or aboral transverse suture of the compound plate, and reaches it in one of three places, according to the position of the compound plate in the ambulacrum. The line of this ascending suture of the aboral demi-plate may be upwards and outwards, so as to reach the transverse suture, just alluded to, at the position of the adoral pore of the pair of pores which belong to the compound plate immediately above

(Pl. I. fig. 4); or it may be directly upwards, so as to make a right angle with the transverse suture at its junction (fig. 7); or, as is the most usual in the very large plates, the line is upwards and slightly outwards so as to reach the transverse suture nearer the pore than in the last instance.

The Adoral Demi-plate.—This plate resembles the aboral one reversed. It bounds the central primary plate adorally, as far as the lower side of the mamelon, and this structure separates it from the aboral demi-plate. The upper suture of the adoral demi-plate commences at the interradial edge, and passes inwards and slightly aborally to reach the adoral pore of the pair belonging to the primary just above; thence the line of the suture is still inwards and abactinally until the groove of the mamelon is reached immediately actinally to the mamelon. From that spot the inner suture of the demi-plate is bent and directed actinally, and either directly so as to meet the transverse suture of the compound plate (the adoral transverse suture), or obliquely so as to pass to the adoral pore of the demi-plate. In some tubercles an intermediate path is taken, and the line of suture reaches the transverse suture of the compound plate between the adoral pore and the spot situated vertically below the mamelon. The adoral suture of the demi-plate forms the outer or interradial half of the actinal transverse suture of the compound or tubercle-bearing plate.

The Central or Primary Plate.—This plate is the only one of the triple combination which reaches the median ambulacral suture. In shape and size this primary differs entirely from the demi-plate above and below it. For the purpose of facilitating the description of the plate, it may be divided into a low, broad, pore-bearing, outer part, and a very large inner and expanded portion. The first-mentioned part has a curved edge in contact with the interradium, and it is highest there; but further inwards and up the slope of the tubercle, the plate becomes low from above downwards, in consequence of the approach of the two demi-plates to the adoral and the aboral base of the mamelon. Nipped in as is the primary at this spot, still it embraces the whole of the mamelon and also much of the groove around it. This part of the plate forms the most outwardly projecting part of the compound plate, and its pair of pores is placed slightly externally to those of the demi-plates. The remaining part of the plate is the inner or expanded portion which spreads out,

occupies the inner half of the tubercle and of the compound plate, and comes to the inner or median suture of the triple plate. This part is limited aborally and adorally by the transverse sutures common to its plate and the compound plates which are placed immediately above and below.

The Ambulacra near the Peristome.—The tubercle-bearing or compound triple plates become smaller, lower, and narrower towards the peristome, and quite at the margin there is some turning in of the first plate in each zone, and a broad concavity at the ambulacral median line. On either side of the ambulacra is a small branchial cut, and a tall tag which is broad at the margin and long vertically; the latter is partly on an interradium and partly on an ambulacrum, and the cut is a shallow groove without ornamentation.

As the shape of the triple compound plates is lower near the peristome, the two demi-plates and the intermediate primary occupy less vertical space; the pairs of pores are also closer together (Pl. I. fig. 7).

The diminution of the breadth of the triple plate is accompanied by an inward passage, that is towards the median line, of the pairs of pores and also of the now small tubercles. The tubercles close in, as it were, towards the median line, and the closing in of the pairs of pores upon them is accompanied by an alteration in the shape of the demi-plates. They become nearly rectangular in shape, and the angles of their inner sutures are right angles; the direction of these sutures is vertical, and those which are in contact with the poriferous part of the central primary are nearly transverse, and not on the slant as they are higher up.

It was noticed that the pairs of pores are oblique on the edge of the large tubercles; now this obliquity increases in the pairs as they approach the peristome, and the adoral pores have the aboral nearly vertically above them, there being a slight trend externally (Pl. I. fig. 10). The amount of obliquity varies, but it is always decided. Close to the margin, the original first pair of pores usually has its adoral pore as a mere indentation, and it may happen that the third pair is on an oblique line with the second and somewhat pressed out of the order; but there is never any formation of secondary arcs of pairs of pores. The marginal pores are very small and close. The pairs are remote from the interradial edges of their plates which are on the area of the tag.

The Pits along the Median Suture.—As many as five deep pits may be seen in some species of *Cœlopleurus* along the median line of the ambulacra at the spots where the transverse sutures between the consecutive compound plates unite at the median line with the corresponding angular process of the neighbouring plate of the other zone (Pl. I. fig. 7). The first pit is close above the concave margin of the ambulacrum at the peristome, being separated from it by a narrow ridge, or it may be at the margin and even turned slightly inwards.

The pits form a zigzag up the median suture, and it is evident that each one was arched above and that it had a flat broad base.

The sutures may sometimes be seen passing along the hollowed-out deeply-seated surface.

The growth of the test was attended with a downward movement of the whole of the peristomial part, as well as of the other parts of the ambulacra, accompanied, apparently, by absorption of the oldest tubercles, pores, and pits.

The Ambulacra near the Radial Plates.—This part of an ambulacrum extends from the radial plate to the first large tubercle-bearing compound plate. It is narrow in comparison with the interradia on either side and with the part of the ambulacrum at the ambitus; but the poriferous zones are straight and the pairs of pores are increasingly wide apart and the pores are very large, except close to the radial plate (Pl. I. figs. 4 and 5). The pairs are not so distant as are the pores of the same pair, and the direction of the pores of each pair is oblique from within, outwards and upwards. The part of the plates between the pores of each pair is broad, and it is sometimes larger in this region than in that of the great tubercles.

The interporiferous areas are crowded with plates of very diverse shapes and dimensions, so as to resemble a broken and confused mosaic. The apparently disorderly arrangement is greatest midway between the radial plate and the first great tubercle, and great and little plates, some with, and others without, small tubercles, are jumbled together as if there were not room for them all. Some of the plates are largest at their poriferous part; others are larger, and their interporiferous expansion extends far over the median line and also adorally and aborally, so as to exclude the plates immediately above and below from the median line. Or the expansion may not be so great, and there may be some plates which reach the median line in succession, but

which are not great in vertical measurement like those just noticed, but low and yet broad. The arrangement of plates differs in the two zones of the ambulacra, as might be expected; and there is an indefinite alternation of large and small plates in the zones. The large plates are ornamented with small tubercles or with large granules according to the species; but although the tubercles seem to be on alternate plates first in one zone and then in the other, the examination of the weathered surfaces of most specimens shows clearly that there are plates intercalated which destroy this simple and superficial arrangement. It is true that at the ambitus the great plates which carry the tubercles, alternate in the zones: but that is evidently because the full development of the triple-plate combination has occurred. In the region now under consideration, the arrangement in perfect triplets is only foreshadowed. Really there is a method in the apparent confusion of the interporiferous parts of the ambulacral plates.

In the compound plates of the parts of the ambulacra already considered, there are two demi-plates and a large primary; and in the radial region primary plates, alone, exist close to the radial plate; then follow small primaries which are, as it were, kept from growing by the presence of the expanded and future tubercle-bearing parts of other primaries close by, and then a demi-plate is seen here and there. The demi-plate is seen crushed in between two larger plates, and sometimes there are two demi-plates in succession with a large expanded plate close above or below. The poriferous parts of the plates are only exposed to a pressure which is tolerably equal in one direction, and therefore any difference in size relates to symmetrical growth. In the interporiferous areas the growth is most irregular in consequence of the varying size of the plates; and the result is irregular pressure and the prevention of any increase in size of some plates, and their crushing and crowding out and away from the median line. As already mentioned, the ambulacral plates near the radial plate and for some distance down, are small primaries, and every one reaches the median line; but immediately that one of these begins to expand in its interporiferous part, a corresponding want of room is felt by the small primary immediately above, and which is bound to move adorally as others are added above, as well as to endeavour to increase circumferentially. Moving downwards, not increasing in expansion in a zone which increases in breadth, it follows that the small primary becomes a mere appendage to a

poriferous part, does not extend to the median line, becomes a demi-plate, and rests against a large plate with which it will eventually be sutured as part of a triplet. As the increase of small primaries just below the radial plate is constant up to a certain age of the test, it follows that young forms have fewer small primaries than older and more conically-topped tests.

The order of the plates in a medium-sized individual appears to be as follows. The ambulacrum chosen for description is No. III. of Lovén's nomenclature (the ambulacrum immediately to the left of the madreporite, and its zones, are "*a*" and "*b*," Pl. I. fig. 5).

Taking zone "*a*" and noticing the nature of the plates from the radial plate actinally, it is found that there is the following succession (Pl. I. fig. 5):—Plates 1, 2, 3, 4 are small primaries gradually increasing in size. The plate 5, also a primary, is pushed, as it were, aborally, by the aboral expansion of the seventh plate, and just escapes being a demi-plate, for it only touches the median suture by a narrow point. Plate 6 is a demi-plate, separated from the median sutural line by the large tubercle-bearing plate 7; this small demi-plate (6) forms the shoulder of the tubercle, plate 7. Plate 8 is a low primary, and so is plate 9. Plate 10 is a primary which, were there a slightly greater expansion of the next great tubercle-bearing plate, 12, than there really is, would, like its successor plate 11, become a demi-plate. Plate 11 is a small demi-plate and forms the aboral demi-plate of a triple combination-plate. Plate 12 is the central primary of this compound tubercle-bearing plate, and plate 13 is a demi-plate. This combination of plates 11, 12, and 13 somewhat resembles those found lower down.

In zone "*b*" the first three plates near the radial plate are small primaries. Plate 4 is a demi-plate, and it is crowded out from the median line by the abactinal expansion of a small tubercle-bearing plate, 5. These two plates make up a compound plate. Plate 6 is a small primary with the part in the interporiferous area made angular and low.

This is the result of the pressure and crowding incident on the actinal expansion of the tubercle-bearing plate 5. The crowding is not sufficient to make the plate 6 a demi-plate, but it nearly does so. Plate 7 is a low primary with a granular ornamentation.

Plate 8 is a small primary with a low angular part in the inter-

poriferous area; for the expansion of plate 10 extends abactinally so as to crowd out almost the whole of it.

Plate 9, owing to the same cause, is a demi-plate; plate 10 is a large tubercle-bearing plate; plates 9 and 10 form a compound plate; plate 11 is a low primary. The three plates next in succession are a demi-plate, a large primary, and a demi-plate; and this is a perfect combination-plate and is like those at the ambitus.

There is much variety in the succession of the plates in the abactinal parts of the ambulacra of different individuals, and indeed hardly two are alike, and the age of the specimen has evidently to do with the diversity. But it is true that a careful examination of a number of specimens shows that there is order in the apparent disorderly arrangement of the plates, and that the perfect condition of the combination-plates of the ambitus is foreshadowed nearer the radial plate.

In an example of *Cœlopleurus sindensis*, nob., there is a very instructive succession of ambulacral plates near the radial end. In zone "*a*" there is a succession of primaries from nos. 1 to 8 inclusive; the first five are small and the sixth is large, narrow towards the median line. Plate 7 is a large primary, and is expanded towards the median line both adorally and aborally. Plate 8 is also a primary, and, like no. 6, it is contracted at the median line. Now these last three plates form a compound one with the sutures distinct, and there are, of course, three pairs of pores in the multiple plate (Pl. I. fig. 6). The central primary is enlarged towards the median line for a great granule, there being no great tubercles above the ambitus in this species, and the plates above and below are suffering from the pressure of the central primary, but not sufficiently to destroy their development near the median line and make them demi-plates. A little more pressure would make demi-plates of nos. 6 and 8*. The next plate to this set is 9, a small demi, a plate once a primary and which has been interfered with by the growth of the triplet immediately above. This demi is a small independent plate. No. 10 is a demi-plate and forms the first member of a large normal combination of a large primary, 11, and its adoral demi, 12. In the instance of this last set, as in all similar to it, the great develop-

* This combination is of considerable importance in a classificatory sense, as one of us will demonstrate shortly in a communication on the Diadematidæ.

ment of the central primary towards the median line removes every chance of the other plates being other than demi-plates.

In the zone "*b*" the succession is very simple until the eleventh plate, for the plate 1 is a small primary and 2 is a demi-plate, because 3 is a large primary expanding towards the median line. Plate 4 is a low primary associated with 5, a large primary, and 6, a smaller one. These three plates form a combination of small primaries with an intercalated large one; and a little more expansion of the last would have made them demi-plates, that is, it would have cut them off from the median line. 7 is a small solitary primary; and then comes a compound plate made up of 8, a small primary, 9, a large primary expanding towards the median line and not shutting out no. 8, but occluding 10, which is a demi-plate. Then follows a normal plate-combination of 11, a demi, 12, a large primary extending to the median line, and 13, a small demi.

III. *The Radial Plates.* (Plate I. Figs. 4 and 5.)

The radial plates are large and never reach to the periproct; they are broader than high, and the sides which are between the Basals are usually curved, the convexity being outwards. The sides which are free are curved, with the concavity outwards, and the adoral side is slightly incurved, there being a projection in the median line which may produce a double curvature. This adoral part is broad and its edge is thick in well-preserved specimens; and the median projection, which resembles a long narrow arched ridge with an adoral point, overhangs the centre of the edge. There are two small optic pores which penetrate the adoral margin between the internal and the external or back and front edges of the margin, so that they appear as small points on either side of, and below the end of, the projecting median ridge. The pores are separated at their exit from the lower edge of the plate by a delicate intermediate process, which is continuous with the overhanging process already described.

In some specimens the median ridge is made up by the coalescence, more or less perfect, of a series of granules. It sometimes happens that the terminal part of the ridge has been worn and weathered, and then the appearance is given of the presence of a single large external pore; but it is an illusion.

The outer surface of the radial plates is beautifully ornamented

in well-preserved specimens. On a fully developed plate there is the more or less continuous median ridge already noticed, with some separate granules, conical in shape, near the aboral point of the plate and breaking the continuity of the ridge. On either side of this median ridge are two or more raised ridges, separated by sunken or shallow grooves, placed obliquely and directed outwards and upwards to the suture between the radial and basal plates. The ridges and furrows are continuous with those of the Basals, the suture forming a marked thin line of separation. These ridges may be continuous over the radial plate, or they may be interfered with by the presence of granules along their line. A ridge is usually on the flank of the radial plate close to the side edge which is free and adoral to that edge within the Basals. This ridge, seen on both sides of the plates, need not be continuous with any structure of the Basals.

IV. *The Apical Sutures.*

These are beneath very distinct grooves between the Basals and Radials and between the Basals themselves. The grooving interferes with the continuity of the ridges and furrows but does not alter their direction.

In some specimens there is a decided fibrous appearance of the surface of the test in the vicinity of the sutures, and a more or less regular dove-tailing of the angular points of the fibres of one plate occurs with those of the other across the line of suture. This structure also occurs between the sutures of the interradial plates just at the surface of the grooves.

V. *The Obliquity of the Interradial Plates.*

This is very marked, and the transverse sutures of the interradia do not make right angles with an imaginary line passing vertically down the median area (Pl. I. fig. 2). The obliquity of the pairs of pores has been noticed, and it appears that the direction refers to the obliquity of the interradial plates, which pass, not straight across the space, but in a direction upwards and inwards. About midway between the apical system and the ambitus there is a decided obliquity of the outer third of each interradial plate, and the vertical zone of granules and small primaries close to the ambulacra is placed on this oblique part.

Further adorally, the secondary tubercles on the outside of the great tubercles are on an oblique and downward-trending part of the plates. Still lower, and on the actinal surface, the want of a transverse direction in the plates is evident, and in some specimens the plates are clearly oblique to the median line.

VI. *Recent Cœlopleuri.—Cœlopleurus Maillardi*, Mich., sp.

This very beautiful recent species has been found down to the depth of 102 fathoms in the seas to the E. of Africa, of the Philippines, Amboyna, and of the Indian archipelago.

The species was revised by A. Agassiz in 'The Revision of the Echini,' 1872–1874; and since the appearance of that great work there have been important notices of the species in the Report on the Echini of the 'Challenger' Expedition, 1881, p. 60, by the same author.

The description of *Cœlopleurus Maillardi* in the 'Revision' was not accompanied by a drawing of the test, but in the Report of the 'Challenger' Echini there are delineations of the test, the spines, the pedicellariæ, and the jaws.

The alliance of the fossil species *Cœlopleurus Forbesi*, d'Arch., and *C. Maillardi*, Mich., is very close; and the dissimilarities relate to increased height of, and the want of obliquity in, the interradial plates, the absence of regular rows of secondaries between the poriferous zones and the large interradial tubercles, and the delicate nature of the ornamentation in the apical system and median interradial line in the recent form. Agassiz mentions the structures in which there is variation in the different specimens of the recent species; and it is interesting to note that, as a rule, the variation does not link the recent and the fossil forms. Agassiz states, *op. cit.* page 63:—"The principal differences in smaller specimens consist in the proportionally greater width of the ambulacral areas, the absence or smaller number of the more prominent secondaries and miliaries, the proportionally narrower poriferous zone, the indistinctness of the **S**-shaped bands of the median interradial spaces, the slighter and less deep cuts, and the comparatively smaller size of the generative openings."

The recent form is not so tumid as the fossil species, and is comparatively higher, and more rounded and convex above the ambitus; there is not the conical flattening which is seen in the fossil forms. The small primary tubercles reach up in

the ambulacra close to the radial plate in both species, and there are a few secondary tubercles in the abactinal ambulacra in both species. The great tubercles are of the same type, and the pairs of pores of the triplet are wide apart and often intrude upon the flat edge of the base of a great tubercle. The interradial plates are higher than in the fossil forms, and there is no obliquity of the outer parts. The differences between the recent and fossil ambulacra being in matters of detail only, it is important to study these structures in *C. Maillardi*, and to compare them with those of the fossil species. We do not therefore propose to repeat any descriptions which can be found in the work of A. Agassiz, but to offer those new structural details which have been noticed by us.

The Ambulacral Region at the Ambitus.—In zone "*a*" of ambulacrum "IV." the fourth and fifth tubercles from the radial plate are the large ones at the ambitus; the third and the sixth are subequal and are decidedly smaller. The fourth and fifth are the largest tubercles of zone "*b*," and the third tubercle is slightly larger than that of the other zone. All the tubercles have, in this part of the ambulacrum, an expanded thin edge and almost circular base which covers nearly the whole of the compound triple plate, leaving, however, space enough for a miliary or two between the adoral edge of the fourth and the aboral edge of the fifth plate; but there is no such space between the fifth and sixth plates, for their bases almost come in contact in consequence of a slight downward projection of the bases, which just at that spot are a little more sharply curved than elsewhere.

There is also some space in the median area between these great tubercles, but only sufficient to permit of there being some miliaries and very small mammillated tubercles in a single row at the median line, and a small group of the same kind of ornamentation at the angles. It is this grouping that seems to produce the slight departure from the circle of the curvature of the bases noticed above. The shape of the tubercles is that of the fossil forms: there is a broad-based boss sloping up without any tumidity to a narrow top surmounted by a mamelon, which contrasts greatly with the dimensions of the rest, and which is surrounded by a shallow narrow groove, so that the neck of the mamelon is nearly as broad as the mamelon itself.

The largest of the tubercles in a medium-sized specimen is 4 millim. in breadth and the height is not quite 2 millim.

The three pairs of pores to these tubercles are placed in an arc, and each pair intrudes upon the base of the tubercle, and the adoral pore may almost be hidden by it. The pores are small, close, separated by a nodule, and they are surrounded by a peripodium except near the apex. They are placed obliquely, and their direction is outwards and decidedly upwards, so that the aboral pores are really worthy of the name, and this obliquity increases in the actinal great tubercle. The pairs of pores are wide apart, and the distance of the first and second pair is slightly greater than between the second and third. The first pair is placed on the aboral and outer shoulder of the tubercle, and a line drawn across the tubercle from the pair inwards would pass aborally to the groove around the mamelon. The middle pair is either on a level with the middle of the mamelon, or slightly adorally, and the lower pair is close to the lower and outer edge of the base.

Each great tubercle and the plate which it covers is really a triple combination; and the sutures of the three plates are sometimes, but not invariably, slightly indicated as faint groove-like marks passing up the side of the boss from the adoral pores of the pairs. There is no trace of a passage of sutural lines over the top of the mamelon or its base, and it is evident that the ordinary method of union of triple plates seen in the Triplechinidæ does not occur (Pl. I. fig. 9).

On cutting through a specimen of *Cœlopleurus Maillardi* preserved in alcohol, and removing the delicate investing membrane from the inside of the test, the markings of the sutures of the triple combinations become very distinct to view (Pl. I. fig. 8). After drying, the more delicate sutural lines disappear; but there are some media which restore the appearance for a while. It becomes evident on a most superficial examination that the composition of each of the great tubercle-bearing plates at the ambitus is almost the same as that of the fossil species. The sole difference is in the direction of the inner sutural lines of the aboral and adoral demi-plates of the compound plates. And indeed the difference is not a perfect one, for the almost vertical direction of these lines is noticed in some parts of the fossil forms. The difference is of no importance. As in the fossil species, each compound plate covered by a great tubercle consists of three plates, of which the aboral and adoral are small, do not reach the median line, and are

therefore demi-plates, whilst the central plate is a primary of great dimensions.

This central plate has a low poriferous portion, but the rest of it is greatly expanded, so that all the compound plate which is internal to the adoral and aboral demi-plates (that is nearer the median suture of the ambulacrum) belongs to it. The sutures of the demi-plates do not unite in any way. Guided by the view of the sutures of the compound plate as seen from within the test, it is not difficult to trace their line on the outside, either directly or by mapping out (fig. 8). The limitation of the aboral demi-plate to the upper and outer shoulder of the tubercle is very evident, and so is the position of the adoral demi-plate on the lower and outer shoulder of the tubercle. The parts of the plate and tubercle placed between the demi-plates, comprising the slope of the tubercle up to the mamelon, the mamelon itself, and all the rest of the tubercle towards the median line, belong to the great central primary plate of the triplet.

On referring again to the view of the test from within, it may be observed that the marking of the sutures on the inner side of the ambulacra is so distinct that the shape of the compound plates is readily drawn. The compound plate is, taking the largest as the type, high and hexagonal in shape, the aboral and adoral sides being the smallest. Four pairs of pores are in relation to the compound plate, but only three belong to it. The inner or adoral pore of each pair is at the end of a long groove, indicative of the growth of the plate. The aborally placed pair belongs to the tubercle-bearing plate above, and the transverse suture of these successive plates crosses the adoral pore of the pair. The next pair, which is the proper 1, of the triplet, is larger and is situated nearer the interradium than the pair just noticed. Pair 2 is of the same size as pair 1, and the pores are placed almost directly beneath those of the first pair but at some distance. The pair 3 has smaller pores, and they are placed on a vertical line beneath the aborally placed pair, and therefore to a certain extent nearer the median line than those of the pairs 1 and 2 (Pl. I. fig. 8). The inner suture of the aboral demi-plate is seen to pass from the adoral pore of pair no. 1, almost directly upwards, to reach the adoral pore of the last pair of the triplet in relation to the compound plate immediately above.

The corresponding inner suture of the adoral demi-plate passes from the adoral pore of the second pair towards the adoral pore of

the third pair, the line of direction being almost vertical, with, as is the case in the suture of the aboral demi-plate, a slight deviation towards the median line of the ambulacrum. Thus the sutures of the demi-plates do not unite with any from the central plate so as to cross the internal expansion of the compound plate towards the median line. Assisted by these inner sutural lines, there is no difficulty in observing that the arrangement of the plates externally which combine to form the great tubercle-bearing triplets is the same as is seen in the fossil species *Cœlopleurus Forbesi*, d'Archiac.

The aboral demi-plate comes as far as the groove at the base of the mamelon, at a spot almost directly abactinal to the mamelon. The adoral suture of the demi-plate is in contact with the poriferous part of the central primary plate.

Again, the adoral demi-plate extends towards the groove at the actinal edge of the mamelon, and its aboral suture is in contact with the adoral edge of the poriferous part of the great plate.

The suture passes inwards and very slightly aborally up the side of the boss, and it then turns adorally with a rounded angle. The aboral suture starts from the adoral pore of the pair no. 2, and the inner part of it terminates either at the adoral pore of pair 3, or at a spot nearer the median line on the transverse suture between the compound plate and the one immediately below.

There is no doubt that the poriferous zones of the ambulacra are very narrow, especially in the curved parts. The lines of the sutures between the zones and the interradia are hardly to be made out externally, but they are very distinct on the inside of the test. There is no rounding-off of the poriferous parts of the plates towards the interradia when they are seen from within, for the lines of the sutures pass direct from the aboral pore of one pair to that of the next below and above (Pl. I. fig. 8). The only exception to this is where the line of suture trends towards the interradium between the pairs 1 and 2, to meet the transverse suture of an interradial plate.

The Ambulacra between the Large Tubercles of the Ambitus and the Radial Plates.—A well-developed primary tubercle is seen close to the angle made by the pairs of pores below the radial plate, and there are generally three of the same sized tubercles and a larger one above the great tubercles. The distance between the small tubercles increases towards the radial plate, so that the

first and second are further apart than the second and third, and so on.

The ambulacra are narrow at this part, and the pores are by no means straight but in slight arcs; they are large and wide apart, and it is only in relation to the most adorally placed tubercles in this region that they assume the form of decided triplets.

The surface of the ambulacra at this part of the test is very slightly tumid, and it conforms almost to the general curvature of the test; but it is the sunken median area of the interradia that gives the appearance of unusual tumidity to the rest. The bases of the tubercles resemble those of the others lower down; the bosses are perhaps more swollen in the smaller tubercles, but the mamelon of each has its groove and is the counterpart of the others. The number of very small secondaries is slight amongst the higher tubercles, and it seems to increase suddenly between the third tubercle of one side and the fourth of the other.

The adoral pores of the pairs cling to the sides of the bases of the tubercles, especially of the larger. Near to the radial plate the pairs are very oblique and close, but the obliquity and propinquity diminish gradually.

No trace of the structure of the plates of this part of the ambulacra can be distinguished on the outer surface of the test; but the direction of the sutures can be seen inside, and it is comparable with that observable in medium-sized specimens of *Cœlopleurus Forbesi*, d'Archiac.

The following is the arrangement of the plates in ambulacrum IV. Zone "*b*":—

Plate 1, a small primary.
{ 2, a small demi-plate.
{ 3, a primary with an expanded inner part.
4, a small low primary.
5, a small low primary.
{ 6, a small demi-plate.
{ 7, a large primary with an inner expansion.
{ 8, a small low primary.
{ 9, a small demi-plate.
{ 10, a large primary plate with great inner expansion.
{ 11, a demi-plate.
{ 12, a demi-plate.
{ 13, a large primary with expansion.
{ 14, a small demi-plate.

In explanation of these details, it is necessary to state that the

first tubercle-bearing compound plate is formed by the three plates at the top of the ambulacrum, of which the first is, as usual, a primary, the second is a demi, and the third, which, seen from the outside of the test, is closely connected with the tubercle, forms a considerable expansion aborally and beyond the median line of the ambulacrum. The adoral expansion is almost *nil.* The second plate has evidently commenced as a small primary, and has been prevented growing towards the median line by the peculiar expansive development of the third, which is a primary, plate. Then come two primaries in succession; they have no expansions, are low in vertical measurement, and are almost without granules on the outside of the test. A triplet follows corresponding to a tubercle-bearing plate; but the arrangement is not yet that of the compound plates at the ambitus. There is a demi-plate 6, followed adorally by a large primary 7, with the bulk of the tubercle upon it, and the plate extends to the median suture of the ambulacrum, the whole of the inner part of the compound plate belonging to it. No suture crosses this plate from the interradial edge. The next plate, 8, completes the triplet, and it is a low primary that reaches the median line with a narrow termination. It is to be distinguished externally by a minute tubercle being placed on it near the centre of the space between the second and third tubercles. The next triplet consists of plates arranged as is the case lower down, and there is an aboral and an adoral demi-plate with an intermediate expanded primary, which mainly carries the third tubercle from the apex. After this plate there is the same arrangement found as at the ambitus.

Now the triplets extend much over the vertical median line of the ambulacra; and the result is to prevent the development of tubercles side by side near the apex, where there is much pressing and crowding of plates. Hence, on examining the opposite zone of the ambulacrum, zone "*a*," from within, it is found that the following is the succession of the plates:—

Plate 1, a small primary.
2, a small primary.
3, a small primary.
$\left\{\begin{array}{l}\text{4, a demi-plate.}\\\text{5, a large primary.}\\\text{6, a low primary.}\end{array}\right.$
$\left\{\begin{array}{l}\text{7, a demi-plate.}\\\text{8, a large primary.}\\\text{9, a demi-plate.}\end{array}\right.$

In explanation, it is evident that the first three primaries cannot expand; but their downward growth, together with the expansion of the fifth plate, prevented plate 4 from being anything else than a demi. The expansion of plate 5 was not much adorally; and the consequence was that plate 6 did not suffer pressure enough to form a demi, and it remained a primary; suffering, however, from direct pressure from above downwards, and being prevented from increasing in a vertical direction, it became a low plate.

The Peristomial Region of the Ambulacra.—The plates and the tubercles become smaller and closer towards the peristome, and yet, although the plates are lower and narrower from side to side, there is no doubling of the pairs of pores. These are in a series of simple arcs close to the edge of the tubercles, and, except at the lowest of all the tubercles, the arrangement of the pairs resembles that seen higher up the test. There is a little crowding of the lowest triplet, and the first pair of it may be rather more externally placed than is usual elsewhere. As a rule, the arrangement is rather more simple than that seen in the fossil species.

Just outside the poriferous zones is a long and narrow plain "tag," and it reaches from the small branchial cut and ends in a point at some distance aborally. The plain construction of this tag is in marked contrast with the arcs of broadly elliptical peripodia which support the triplets of pairs of pores close by. We do not enter into the consideration of the function of the tag, as it will be treated of by one of us on a future occasion.

The suturing of the plates of the peristomial triplets is on the same plan as that of the compound plates of the ambitus; the demi-plates are lower and broader, however, but they are placed in the same positions relatively to the great primary plate as in the ambital regions.

The auricles are small, disconnected, and there is no union by a raised plate crossing the interradia.

At the peristomial end of the ambulacra, the deep pits for the sphæridia are very prominent objects in the line of the median suture and at those places where it is joined by the transverse sutures. When the ambulacral plates of either side are separated, so as to divide the sphæridial pits along the median line, the separated faces of the median suture show deep sphæridial

pits and intervening projections; but, as A. Agassiz has noticed, there is no structure at that spot like that of the Temnopleuridæ.

VII. *The Interradial Plates and their Sutures.*

The interradial plates which succeed the small ones immediately around the apical system are remarkably high and broad, and thus they differ from those of all the fossil species. The slight development of secondary tubercles between the great primary tubercles of the interradia and the poriferous zone of the ambulacra, appears to prevent that breadth and obliquity of the plates which is seen in the fossil forms. The great tubercles are of the same shape as those of the ambulacra; and when the inside of the test is examined, the surface beneath them is seen to be hollowed.

The suturing of the plates together is excessively close; and in the specimen which one of us has prepared for the National Collection, and which had been kept in alcohol, the test often broke across the plates themselves instead of at the sutural lines.

The transverse sutures between the interradial plates separated much more readily than those of the vertical or median zigzag line. Any separation along these median sutures is hard to get, and there is an evident and very interesting reason.

On the adoral suture of every interradial coronal plate there is a series of knobs, and these prominences of the tissue of the plates are either hemispherical or elongated. There are also small pits placed here and there, between the knobs, and the whole surface of the sutural face is somewhat swollen (Pl. I. figs. 11 & 12).

On the aboral faces of the sutures, on the contrary, there is a series of depressions resembling pits or elongate holes, and the presence of a few knobs in the midst is evident.

This arrangement of the adoral and aboral faces of the sutures resembles, to a certain extent, the dowelling of *Temnopleurus*, described by one of us in a former communication to the Society, but the knob-and-socket structure is not so perfect *. It is evident that the knobs and elongate processes fit into the sockets and holes of the face of the plate which is opposed to them.

* Journn. Linn. Soc. vol. xvi. p. 343 (1881).

The transverse sutures of the interradial coronal plates near the apex are well marked with knobs on one side and with pits on the other. The dowelling is as complete as in any Temnopleurid. But lower down and near the ambitus, the sutural arrangement ceases. We have not been able to see this knob-and-socket structure in the ambulacra, for we have not been able to sacrifice an ambulacral area on purpose.

The adoral faces of a basal plate and of the contiguous radial plate are covered with knobs; but it does not appear that this is universal, for whilst in some interradia the adoral faces of the transverse sutures of the plates close to the apex are knobbed, others have sockets.

VIII. *The Radial Plates.*

On carefully denuding one of the radial plates of the specimen preserved in alcohol, the structure of the adoral edge of the plate was rendered visible. The adoral margin of the plate is not a perfect arc, for there is a protuberance in the median line which has a triangular piece underneath it, the outer edges of which are in contact with the aboral margins of the first poriferous plates of the ambulacrum. The protrusion has a broad base, adoral to a glassy tubercle, and there is a narrow and long process in the median line which, with the triangular piece, forms the centre of the adoral margin of the plate. A very minute optic pore is seen on either side of the central process, close to the free edge of the plate. When the radial plate is examined from within, there appears a deep pit close to the adoral edge, and it is evident that the nerve divides and that, as in the fossil forms, there are two optic pores which open obliquely, and do not appear on the outer or coloured surface, but on the adoral edge of the plate. The pores look downwards, or adorally and slightly outwards.

The specimens show faint ridges and furrows on the radial plates, crossing to them from the Basals, and interfered with to a certain extent by the baso-radial sutures. A low ridge is also in the median line, and the knob alluded to terminates it.

Genus Arbacia, *Gray.*

IX. *Structure of the Ambulacral Plates.*

In *Arbacia*, Gray, the ambulacral plates, except in the neigh-

bourhood of the apex, are compound plates as in the Triplechinidæ, that is to say, each is built up of several poriferous plates. The grouping of these plates and their relations *inter se* are, however, very different in the forms under notice and the group to which we have just referred.

In most of the species of *Arbacia* (e.g. *A. stellata*, *A. punctulata*, *A. pustulosa*) there are three poriferous plates in each compound ambulacral plate. The adoral and aboral plates of this triplet are small demi-plates, and occupy scarcely more than half the length of the ad- and aboral margins of the compound ambulacral plate respectively; and the mean depth of these plates may be roughly stated as being about one third of the depth of the whole compound ambulacral plate. It thus follows that the greater part of the compound ambulacral plate (approximately two thirds) is formed of one large primary poriferous plate, which occupies the whole of the inner half of the compound plate, and which also extends as a narrow strip between the two small demi-plates above mentioned, its outline being more or less spade-shaped, or fancifully suggestive of an old-fashioned sugar-spoon.

The forms and posture of these plates differ more or less in the different species of *Arbacia*. After the preliminary remark that the compound plates may be best studied at a little distance above the ambitus, and from thence to the peristome, we proceed to examine *Arbacia pustulosa*.

In this species the whole ambulacral plate is subject to a more or less considerable adoral flexure at the commencement of the poriferous region, which will be seen on referring to fig. 1 (Pl. II.). The aboral poriferous plate, which is a demi-plate, has a rounded extremity internally; the suture commences almost at a right angle to the aboral margin of the whole ambulacral plate, mounts the boss of the primary tubercle, curving meanwhile, and the bend being completed near the summit of the boss, the suture thence proceeds in a direct but inclined line to the outer end of the compound plate. The aboral demi-plate is somewhat enlarged at its outer end, as shown in the figure. The adoral demi-plate, on the other hand, is enlarged at its internal end, and in consequence presents somewhat of a pyriform outline; its suture mounts the base of the boss of the primary tubercle, is rather rapidly bent with a well-rounded curve until at a right angle to its initial direction, and thence proceeds in a slightly sigmoid

curve up to the outer end of the plate. Consequent on the forms of the two small demi poriferous plates above described, the intermediate portion or prolongation of the large primary poriferous plate is inclined at an angle adorally, and its outer end is slightly enlarged (see fig. 1). The enlargements of the three plates above referred to correspond to the position of the relatively large, suboval or palette-shaped peripodia.

At a few plates above the ambitus the three peripodia with their pairs of pores form an almost vertical, and very slightly curved, arc; at the ambitus the curvature of the arc is more definite; and below that position the peripodium of the adoral demi-plate is seen to have assumed a much more internal position in relation to the other peripodia of the compound ambulacral plate to which it belongs. (Fig. 1 represents the fifth and sixth tubercle-bearing plates, counting from the peristome.) This apparent moving inwards of the adoral peripodium, away from the outer end of the plate, is continued in each succeeding ambulacral plate down to the peristome. Below the ambitus the peripodium of the aboral demi-plate also moves slightly inwards, away from the outer margin of the ambulacral plate, but to a much less degree. The peripodia as they approach the mouth maintain with but very slight diminution their uniform size; the plates, however, upon which they are borne, in the four or five ambulacral plates next to the peristome, decrease successively in depth and become mere band-like strips. Consequent on this and the inward movement of the pores above referred to, the crowded and almost transverse arrangement of the peripodia near the peristome is produced. When a suitable preparation is examined under the microscope, it is found that although the two or three ambulacral plates next the peristome have more or less lost their superficial individuality, the constituent poriferous plates are still distinguishable as independent band-like strips occupying their original relative position, and that the peripodia are expanded, and poured over superficially as it were, occupying an area whose diameter is much greater than the mean depth of the plate to which they belong. Figs. 4 and 5 illustrate these observations in another species; and a comparison of the two will at once indicate how the crowded mass of peripodia near the peristome may be reduced to order, in conformity with their disposition at the ambitus. It will be readily observed that the more or less regular arrangement in obliquely transverse lines

or arcs is in reality a secondary formation caused by the movement of the peripodia and the modification of the plates above noticed. It may be conjectured that the two more adoral poriferous plates of the first compound ambulacral plate have been resorbed or merged in the peristomial rim, and that the peripodium of the aboral demi-plate alone remains, its adoral foramen notching the peristome. The peripodium of the adoral demi-plate of the second ambulacral plate is also very near the margin, and may be said to partially notch it. The growth stages upon which this merging and obliteration of plates depend have been carefully described by Lovén (*op. cit.*) in the case of *Strongylocentrotus drœbachiensis*, and need not be recapitulated here.

In *A. stellata* the same general arrangement and relative proportions of the poriferous plates in the ambulacral compound as those above described occur. The outline, however, of the plates is different (see fig. 5). It will be observed that the small ad- and aboral poriferous plates—the demi-plates—of the triplet have a straight or truncate inner end, parallel to the outer line of the ambulacral area, the suture-line mounting the base of the boss at a right angle to the ad- and aboral margins of the compound ambulacral plate respectively, and is then sharply bent, forming an angle less than a right angle, to direct its course towards the outer margin of the ambulacral area. The outline of the demi-plates is thus more or less trapezoid, and their greatest depth is at their inner end. In consequence of this the intermediate portion of the main primary poriferous plate is somewhat cuneiform, expanding as the margin of the ambulacral area is approached, where its greatest depth is situated. The same narrowing of the plates in the neighbourhood of the peristome takes place as already noticed in *A. pustulosa*, and the peripodia in consequence become crowded (see fig. 4). Their arrangement may be readily formulated by comparing them with fig. 5.

In *A. punctulata* the ambulacral structure approaches in character very closely to that of *A. stellata*, as reference to fig. 2 will suffice to show.

The manner in which the ternary compound ambulacral plates, with which we are now concerned, are formed, may be well studied on the upper portions of the ambulacral areas of any of the species of *Arbacia* above mentioned; and their development is highly instructive. In the neighbourhood of the apical disk

(see Pl. II. fig. 3) all the poriferous plates are simple and entire—that is to say, primary plates which extend from the median suture of the area to its outer margin, each with a single pair of pores. At a very short distance from the apex—on the fifth or seventh plate from the radial (ocular) plate in the case of *A. stellata*—there is an unmistakable tendency to form binary compound plates, which manifests itself in the greater increase of the plate in question than in its immediate neighbours of the same column. This enlargement of the plate takes place at its inward end, in such a way as to environ the whole of the inner end of the next aboral poriferous plate, thus intercepting the entry of that plate into the median suture, and preventing its further growth in that direction, causing it to remain a small or demi-plate henceforward. It may also be seen that one, or sometimes two, simple primary plates intervene between each of the succeeding binary compounds thus formed. These ultimately become the adoral small or demi-plates of the ternary compounds, consequent on an adoral encroachment of the main primary poriferous plate, similar to its aboral increase just noted. It will further be observed that the increased primary poriferous plate in one column of the ambulacrum is opposite to a small poriferous plate in the adjacent column, the growth of which it appears to have prevented, and thus perhaps determines the reason why the small primary plate (at this period still an entire one) which underlies, or is adoral to, the binary compound plate in the adjacent column, ultimately becomes the adoral member or small demi-plate in the mature ternary compound. This alternate increase and debarred growth is necessarily reciprocal in the two columns. It is not till near the ambitus that the true fully-formed ternary compounds, previously described, are met with. In a small test with a diameter of 33 millim., the 23rd, 24th, and 25th poriferous plates constitute the first true typical ternary compound ambulacral plate; though, critically considered, the two preceding triplets might essentially be almost ranked as such.

In *A. punctulata* the first true ternary compound ambulacral plates are as near to the ambitus as in *A. stellata*; the 23rd, 24th, and 25th primary poriferous plates, or even the 26th, 27th, and 28th from the apex, constituting the first typical triplet.

In *A. pustulosa* the ternary plates have the appearance of being somewhat further removed from the ambitus, for although when counted from the apex the position of the first typical triplet

corresponds numerically with that in *A. stellata* and *A. punctulata*, several of the preceding series form distinct incipient triplets.

It is especially interesting to note how closely the two species *Arbacia stellata* and *A. punctulata* resemble *Cœlopleurus* in their ambulacral structure, even to the trapezoid form of the small or demi poriferous plates; and the significance of the fact is further enhanced when it is remembered that these two species of *Arbacia* approach *Cœlopleurus* much nearer in general character and habit than does *A. pustulosa*. The same remark also applies to *A. spatuligera* and *A. Dufresnii*, the ambulacral structures of which conform so closely to what has been above described, that reference in detail is unnecessary for the present purpose. It is probable that *A. alternans*, Troschel, will stand in the same category, if indeed the species is really an independent one.

X. *Ambulacra of* Arbacia nigra.

In concluding these notes on the ambulacra of *Arbacia*, we would remark that the form known as *A. nigra* presents an altogether different structure from that of the group of species we have been discussing. The compound ambulacral plates in this species are composed of four or five poriferous plates, and it will be seen on reference to fig. 6 that it is the lowest or adoral poriferous plate which is the main primary and occupies the greater portion of the compound plate, the other poriferous plates being all small or demi plates, the main primary plate mounting up and occupying nearly a third of the aboral margin of the compound ambulacral plate. This arrangement, whilst recalling that of some Triplechinidæ, has at the same time a definite character of its own. This difference of structure in our opinion removes *A. nigra* from the genus *Arbacia*—a question to which we shall refer in Part II. of this paper.

XI. *Structure of the Vertical Sutures of the Interradia.*

A noteworthy system of dovetailing or "dowelling" occurs in the median interradial suture of the coronal plates in *Arbacia*. This consists of a series of knobs or eminences situated on the adoral facet of the inner end of the interradial plates, and these fit into corresponding sockets or pits on the aboral facet of the adjacent plates in the neighbouring column. Each coronal plate has consequently knobs on its adoral facet and pits on its aboral

facet. These structures recall, more or less vividly, the system of dowelling by knobs and sockets, previously described by one of us in Temnopleuridæ *; in the case of *Arbacia*, however, they are confined to the vertical sutures entirely, no trace whatever of their existence being found on the horizontal sutures which separate the successive plates in a column: or in any case only a slight granular surface, presenting, on separation, a faintly carious appearance.

The special form of the knobs and pits varies in the different species that we have examined, and would appear to constitute a good secondary specific character; it also varies a little, but in a definite manner, according to the position of the plate upon which it occurs—in other words, the dowelling on the abactinal surface is slightly different from that on the actinal surface. This structure appears to exhibit its maximum development on the abactinal surface about midway between the ambitus and the apex.

On examining the seventh interradial plate (counting from the apex) of *A. stellata*, a number of small round semiglobular prominences will be seen forming more or less regularly three lineal series, which occupy about half the area of the facet. The eminences and pits on the respective facets are confined to a well-defined area, between which and the edges of the facet that correspond to the internal and external surfaces of the plate respectively a straight smooth margin intervenes; the knobbed and pitted area being rather nearer to the internal than the external surface of the plate (see fig. 7). Nearer the ambitus the granular knobs are more numerous and less regular in their disposition.

In *A. punctulata*, on the seventh plate from the apex, instead of the semiglobular rounded knobs found in *A. stellata*, we have a series of larger and more elongate prominences, either oblique in position or subparallel with the lateral sides of the facet, the individual prominences becoming narrower and suboval in contour as they approach the end of the facet adjacent to the aboral facet of their own plate (see fig. 8). Roughly speaking, they may be said to form only a single series (though there is a slight tendency to double in the part where the smaller-sized knobs just mentioned occur); and the area they occupy is narrower than the area occupied by the knobs in *A. stellata*.

* P. Martin Duncan, Linn. Soc. Journ., Zool., vol. xvi. pp. 343–358.

On the plates at the ambitus and below, these broad prominences become broken up into rounded knobs, very like the structure in *A. stellata*, although they do not appear to form more than two series, and generally one or more of the broader "uniserial" prominences remain.

The plates of the apical system are united together by a dowelling of numerous small semiglobular knobs, less regular in their disposition than any of the foregoing; the basal (genital) plates bearing only knobs, whilst the radial (ocular) plates bear pits only.

In *Tetrapygus* (*Arbacia*) *nigra* the sutural dovetailing is very remarkable, and highly developed. On the seventh plate from the apex, it consists of a single series of large, broad, subtriangular, plate-like prominences arranged transversely on the surface of the facet, and slightly inclined aborally in relation to its plane (see fig. 9). As the plates approach the ambitus, the plate-like prominences gradually become broken up into rounded elongate prominences, one half of the plate-like form remaining, whilst the other is formed as it were into the smaller, but equally long, prominences. Below the ambitus, on the actinal surface, the breaking up is still further carried out, and we find a number of small granule-like knobs arranged in wavy lines across the plate, amongst which some apparent confluence is visible.

In all these cases, the aboral facet of the adjacent plate in the neighbouring column of the interradium to which the knobbed facet is apposed, is furnished with exactly correspondent depressions or pits, into which the prominences fit.

In the species we have been discussing, there is a similar system of dowelling, but less developed, at the junction of the ambulacral plates and the interradial plates, here present in the form of small uniform rounded granule-like knobs; and the knobs are all borne on the ambulacral plates, whilst the adjacent end of the interradial plates bears only pits.

There is also a similar system of dowelling in the vertical or median zigzag suture of the ambulacral area, the knobs being borne on the aboral facet of the plate, whilst the pits are borne on the adoral facet, the reverse of what takes place in the median interradial suture. The dowelling in the median ambulacral suture is comparatively feebly developed, and resembles that between the ambulacral and the interradial plates, having, in some instances, at first sight little more than a "carious" appearance.

Radial Plates.—These are upon the same plan as those of *Cœlopleurus*, and as the peculiar central ridge and the position of the two optic pores have been described by Lovén (*op. cit.* pp. 66 and 67), it is not necessary to do more than refer to that careful naturalist's descriptions.

XII. *Comparison between the two Genera.*

It is evident from the descriptions given of the ambulacra, radial plates, and interradia of the fossil and recent species of the genus *Cœlopleurus* and of the species of *Arbacia*, that these forms have a great similarity of structure. In all, with the exception of *Arbacia nigra*, the compound plates of the ambulacra are formed of an adoral and an aboral demi-plate with a large central primary plate.

In all the forms the optic pores are double, and the perforation is in the adoral edge of the plate, a process separating the pores. In all the forms the median or vertical sutures of the interradia are marked with knobs or ridges, which correspond with sockets or short grooves on the opposed plate-edges. This kind of dowelling is even seen in the ambulacra of *Arbacia* and along the transverse interradial sutural edges of *Cœlopleurus*.

Arbacia nigra is an exceptional species, and, as will be shown in Part II. of this communication, belongs to a different genus from the *Arbacia*.

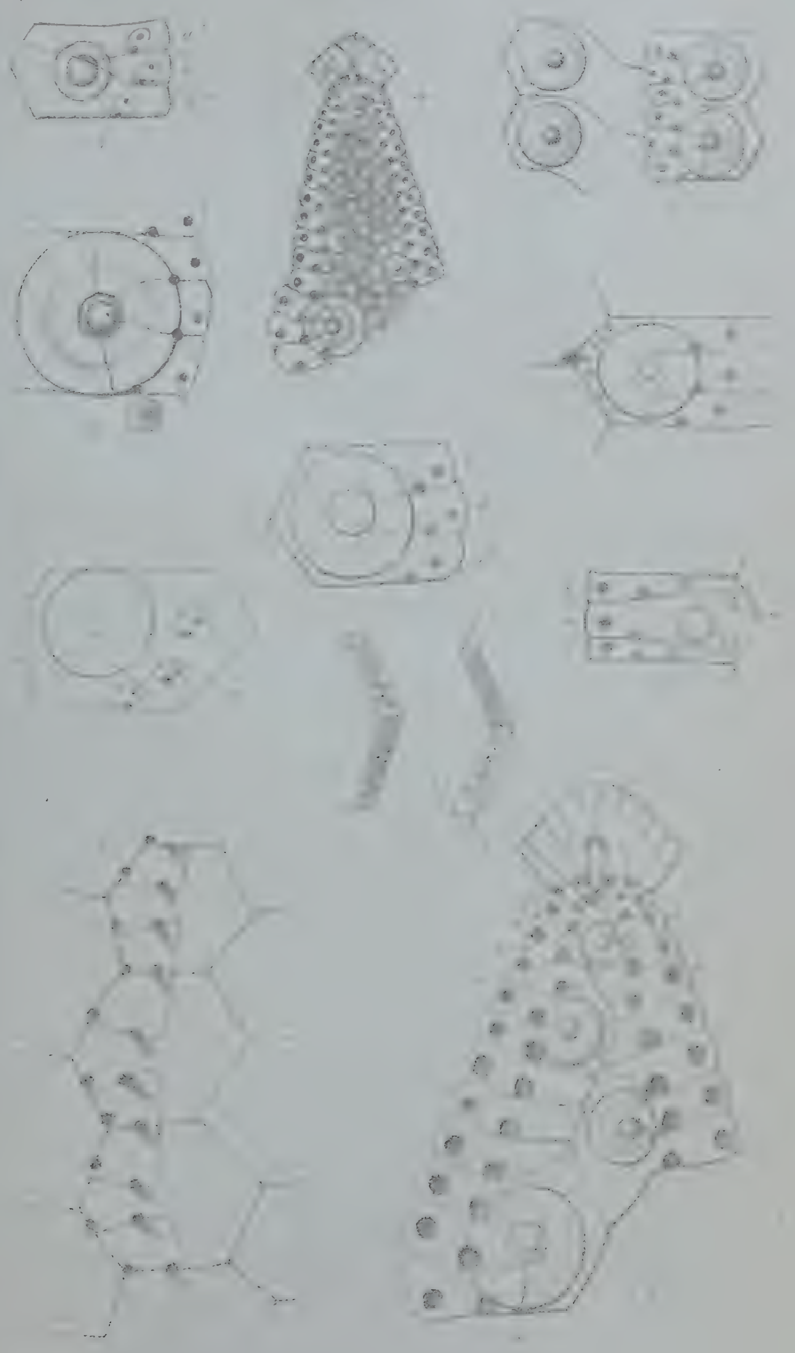
It is of importance to remember that *Cœlopleurus* was the first of the two genera, and that there were species with the peculiar ambulacra in the Eocene, Oligocene, and Miocene; that the recent species from the Indian seas only differs from the Miocene form in having high and not oblique interradial plates; and that all the species of *Arbacia* which were examined, except one which other authors have eliminated, present no greater differences than can be accounted for on the theory of descent. The *Arbaciæ* are recent forms.

DESCRIPTION OF THE PLATES.

Plate I.

Fig. 1. *Strongylocentrotus drœbachiensis.* A compound ambulacral plate from a young example. a', the aboral primary poriferous plate; a'', the adoral primary; b, the intermediate demi-plate. Magnified.

2. *Cœlopleurus Pratti.* Compound ambulacral plates and adjacent interradial plates from the region of the ambitus. Magnified.



STRUCTURE OF CŒLOPLEURUS.

Hanhart imp.

Hanhart imp

Fig. 3. *Cœlopleurus equis.* A compound ambulacral plate from the region of the ambitus. *a*, the large primary poriferous plate; *b'*, the aboral demi-plate; *b''*, the adoral demi-plate. Magnified.

4. *Cœlopleurus sindensis.* Radial plate and neighbouring abactinal region of the ambulacrum. Magnified.

5. Radial plate and abactinal portion of the ambulacrum, to show the manner of the formation of the compound ambulacral plates. Magnified.

*6. An incipient compound ambulacral plate, formed of the 6th, 7th, and 8th primary poriferous plates. Magnified.

7. *Cœlopleurus Maillardi.* An ambulacral plate near the peristome, showing the broad plates and a spheridial pit. Magnified.

8. Portion of the ambulacrum IV., seen from within. Magnified.

*9. One of the large tubercles. Magnified.

10. Arrangement of the peripodia at the peristome. Magnified.

11. The end of an interradial plate, in the median suture, showing the knobs and pits. Magnified.

12. The corresponding facets of the two adjacent plates in the neighbouring column, furnished with reciprocal pits and knobs, into which those of the plate shown in fig. 11 fit.

Plate II.

Fig. 1. *Arbacia pustulosa.* Compound ambulacral plates from the region of the ambitus. *a*, the large primary poriferous plate; *b'*, the aboral demi-plate; *b''*, the adoral demi-plate. Magnified.

2. *Arbacia punctulata.* A compound ambulacral plate from the region of the ambitus. Magnified. The same lettering as the above.

3. *Arbacia stellata.* Radial plate and abactinal portion of the ambulacrum IV., to show the manner of the formation of the compound ambulacral plates. Magnified.

4. Portion of an ambulacrum and adjacent interradial area near the peristome, to show the arrangement of the peripodia. Magnified.

5. The same, showing the constitution of the compound ambulacral plates. Magnified.

6. *Tetrapygus (Arbacia) nigra.* A compound ambulacral plate. *a'*, the primary poriferous plate; *b'*, *b''*, *b'''*, the demi-plates. Magnified.

7. *Arbacia stellata.* The end of the 7th interradial plate from the apex in the median suture. The adoral facets with knobs only, the aboral with pits. Magnified.

8. *Arbacia punctulata.* The end of the 7th interradial plate from the apex in the median suture. Magnified.

9. *Tetrapygus (Arbacia) nigra.* The end of the 7th interradial plate from the apex in the median suture. Magnified.

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* In the lettering of Plate I. the numbers to figs. 6 and 9 have been inadvertently misplaced, and should be transposed.

On the *Colydiidæ* collected by Mr. G. Lewis in Japan. By DAVID SHARP, M.B. (Communicated by GEORGE LEWIS, F.L.S.)

[Read 15th January, 1885.]

(PLATE III.)

NOTHING was known of the Colydiidæ of Japan previous to Mr. George Lewis's explorations there; but these have shown that the Japanese archipelago is fairly rich in the Xylophagous insects constituting the family of Coleoptera we are now dealing with. This singularly successful collector has discovered in Japan no less than thirty-five species of the family, which is a large number when we recollect that Europe, which has been thoroughly explored for these insects by many entomologists, has only produced about fifty species, and America, north of Mexico, has not yet been proved to nourish so large a number as this latter. As the Colydiidæ are small insects, usually rare, and many of them of habits rendering their capture a matter of great difficulty, we may be sure that Japan has still a considerable number of species in addition to those met with by Mr. Lewis. Indeed we may take it for ascertained that the Japanese archipelago in proportion to its area is richer in Colydiidæ than either Europe or North America. Mr. Pascoe has worked out (Journ. of Ent. ii. pp. 121–143, Pl. viii.) the Colydiidæ collected in the Austro-Malay region by Wallace, and informs us that fifty species were obtained in that region. Of the thirty-five species detected by Mr. Lewis, twenty-nine have not been found elsewhere, fivee occur also in Ceylon, and one species is considered to be not specifically distinct from one of our European insects.

The family Colydiidæ is one in which genera are very numerous in proportion to the species; and I have considered the thirty-five species found in Japan as representing no less than twenty-four genera. Of this number eight appear, as far as I know at present, to be peculiar to Japan, viz. *Sympanotus*, *Pseudotarphius*, *Glyphocryptus*, *Labromimus*, *Acolophus*, *Cylindromicrus*, *Cautomus*, and *Thyroderus*. Six—*Colobicus*, *Cicones*, *Xu-*

thia *, *Pycnomerus*, *Philothermus*, and *Cerylon*—must be considered as widely distributed. Four others—*Neotrichus*, *Teredolæmus*, *Leptoglyphus*, and *Ectomicrus*—are found in Ceylon as well as in Japan; while one, *Trionus*, occurs in Japan, Ceylon, and India. Four—*Ithris*, *Gempylodes*, *Erotylathris*, and *Dastarcus* †—may be looked on as more or less peculiar to the Austro-Malay region; and the remaining genus, *Endophlœus*, is characteristic at present of the Nearctic and Palæarctic regions.

From these data it would seem that the Colydiidæ of Japan are more allied to those of Ceylon than to those of any other region; and this conclusion is strengthened by the fact that several other species and genera find their nearest known allies in Ceylon. On the other hand, it must be borne in mind that we know next to nothing of the Colydiidæ of China and India, and that it is very probable that many of the resemblances between the Ceylonese and Japanese forms may prove to be instances of relationships between forms widely distributed in Eastern Asia. All that we are entitled then to conclude at present is, that there is but slight affinity between the European and Japanese Colydiidæ; that there is a considerably greater relationship with Ceylon; and that there may probably be really a wide distribution in the Oriental region of the forms common to these two provinces.

The Colydiidæ being, as previously remarked, insects of small size and very retiring habits, we of course as yet know but few of the forms actually existing in the world; the classification of the family therefore is in a rudimentary and unsatisfactory condition. I have in the main followed the arrangement of Erichson (Nat. Deutsch. Ins. iii.), except that his group Colydiini must be suppressed, as founded on erroneous observation. Horn (Proc. Am. Phil. Soc. xvii. p. 555 *et seq.*), in his Synopsis of the Colydiidæ of the United States, has proposed to retain the group

* *Xuthia*, Pascoe, appears to be not sufficiently different from *Eulachus*, which itself is so near to *Bitoma* that its suppression has been proposed by Horn and Leconte, but the latter course I think premature as yet.

† This genus has recently been redescribed as new by Fairmaire under the name *Pathodermus* (Ann. Soc. Ent. Fr. 1881, p. 79); although some of M. Fairmaire's supposed new species of it, six in number, are no doubt synonymous with some of the previously described Dastarci, yet others are no doubt new, and we learn from these that the genus extends in the west as far as Syria and Zanzibar; still it must be treated at present as chiefly an Oriental genus.

Colydiinæ by altering its definition, and has also proposed a new group "Deretaphrini." The Colydiini, as defined by Horn, and the Deretaphrini are evidently, however, not sufficiently distinct; and I propose consequently at present to fuse them in one group, to be called "Deretaphrini," as it is clearly convenient to suppress the group "Colydiini," and consequently its name, altogether: a source of considerable confusion in the study of the family will be thus eliminated.

Classified List of the Species of Japanese Colydiidæ.

Tribe Synchitini.

† Neotrichus, n. gen.
N. hispidus, n. sp.
Endophlœus, *Er.*
E. serratus, n. sp.
Sympanotus, n. gen.
S. pictus, n. sp.
Pseudotarphius, *Woll.*
P. lewisii, *Woll.*
Glyphocryptus, n. gen.
G. brevicollis, n. sp.
Labromimus, n. gen.
L. variegatus, n. sp.
† Colobicus, *Latr.*
C. emarginatus, *Latr.*, var.
C. granulosus, n. sp.
Acolophus, n. gen.
A. debilis, n. sp.
† Cicones, *Curt.*
C. oculatus, n. sp.
C. oblongus, n. sp.
* C. niveus, n. sp.
* C. minimus, n. sp.
* C. bitomoides, n. sp.
† Trionus, n. gen.
* T. opacus, n. sp.
† Xuthia, *Pasc.*
* X. parallela, n. sp.
X. niponica, *Lew.*
Ithris, *Pasc.*
I. sculpturata, n. sp.

Tribe Deretaphrini.

† Gempylodes, *Pasc.*
G. lewisii, n. sp.
Cylindromicrus, n. gen.
C. gracilis, n. sp.
† Teredolæmus, n. gen.
T. guttatus, n. sp.
(Teredus) politus, *Lew.*

Tribe Bothriderini.

† Leptoglyphus, n. gen.
L. vittatus, n. sp.
Erotylathris, *Motsch.*
E. costatus, n. sp.
† Dastarcus, *Pasc.*
D. longulus, n. sp.

Tribe Pycnomerini.

† Pycnomerus, *Er.*
P. vilis, n. sp.
P. sculpturatus, n. sp.

Tribe Cerylonini.

Philothermus, *Aubé.*
P. depressus, n. sp.
† Ectomicrus, n. gen.
E. rugicollis, n. sp.
E. pubens, n. sp.
† Cerylon, *Latr.*
C. crassipes, n. sp.
C. minimum, n. sp.
C. curticolle, n. sp.
Cautomus, n. gen.
C. hystriculus, n. sp.
Thyroderus, n. gen.
T. porcatus, n. sp.

* These species occur in Ceylon.
† These genera occur in Ceylon.

Neotrichus, nov. gen.

Corpus angustum, caput exsertum; antennæ liberæ, 11-articulatæ, clava biarticulata; coxæ approximatæ; abdominis segmentum primum ventrale

sequente parum longius; tibiæ ecalcaratæ; tarsi articulis tribus basalibus minutis æqualibus, articulo ultimo crasso elongato.

Antennæ short, first joint thick, concealed from above, second joint globular, third small, much narrowed from apex to base; 4–9 each quite small, the first of them slightly, the last of them considerably, shorter than long; two terminal joints forming an abrupt club, the pubescent terminal joint being evidently narrower than the tenth. Head more than usually exserted, with prominent eyes. Thorax quite destitute of antennal grooves or impressions. Each pair of coxæ only slightly separated, extremity of prosternal process turned upwards. First ventral segment in the middle only slightly longer than the following. Tibiæ hispid externally, rather more slender at the apex, not spinose there. Femora thicker at the knees.

The genus is somewhat difficult of location in Erichson's system; if it be placed, as it would appear from the systematic characters that it should, among the genera at the commencement of the Synchitini, near *Diodesma*, then it is very different from any of its neighbours.

NEOTRICHUS HISPIDUS, n. sp. (Plate III. fig. 1.)

Fuscus, setulis erectis griseis hispidus, angustulus subparallelus; prothorace elongato, posterius inæquali, lateribus in medio subconstrictis; elytris profunde crenato-striatis, interstitiis angustis. Long. 4–5 millim.

Head narrower than the thorax; the latter longer than broad, with uneven surface, but without distinct depressions or elevations; the front angles rounded, not prominent; the sides irregular, presenting a shallow broad constriction at the middle; the surface hispid; the setæ most conspicuous at the sides, where they project outwards. Elytra elongate, narrow and parallel, with deep sculpture forming quite irregular series, with narrow, definite, but only slightly elevated interstices which bear erect setæ. Under surface quite dull, coarsely punctate; the setæ on the outer edges of the tibiæ very conspicuous.

Nagasaki, Oyayama, and Hitoyoshi, on Kiushiu; Kashiwagi and Nikko, on the main island.

ENDOPHLŒUS SERRATUS, n. sp.

Parum convexus, rufus, indumento obscuratus, suboblongus, superficie valde inæquali; prothoracis lateribus rotundatis, posterius fortiter angustatis, marginibus serratis: elytris tuberculatis, marginibus crebre denticulatis. Long. 4–5 millim.

This species is allied to *E. exsculptus*, but has abundant points of specific distinction. The thorax is lobed in the middle in front, deeply emarginate on either side above the eye, so that the front angles appear very prominent; its margins are very ragged, but the serrations do not extend to the base, the rough margin ceasing in front of the narrow basal portion, so as to give space for the movement of the front legs; the surface exhibits also two irregular, not much elevated, costæ. The elytra bear numerous coarse rough tubercles, each surmounted by a seta, and between the tubercles numerous smaller asperities, and there are a few oblong, depressed, smooth spaces; the side margins bear numerous elongate denticles, each terminated by a seta. The tibiæ are rather broad, compressed, their outer margin armed with scales that are scarcely prominent. The surface has always the sculpture more or less obscured by a coating of some exudation or incrustation, but the description is drawn from a specimen from which this has been removed.

Hitoyoshi, Yuyama, Idzu, Miyanoshita, and Kurigahara.

Sympanotus, nov. gen.

Corpus oblongum; caput parum receptum; antennæ 11-articulatæ, articulo basali subcondito, clava parum abrupte biarticulata. Tibiæ lineares, ecalcaratæ, tarsi articulis tribus basalibus subæqualibus. Metasternum elongatum.

Although evidently near to *Endophlœus* in its characters, this will, I think, prove to be a quite distinct genus, the tibiæ being slender, not at all compressed, and the sculpture and clothing, as well as the form of the various parts, all different from what obtains in *Endophlœus*. The eyes are prominent, and the groove for the base of the antenna so short that it may be said to be absent; the apex of the mandible is divided; the prosternal process prolonged a little behind the coxæ; all the coxæ only slightly separated; the first ventral segment in the middle longer than the following one, but behind the coxæ rather shorter than it.

Sympanotus pictus, n. sp. (Plate III. fig. 2.)

Oblongus, subparallelus, nigro-fuscus; prothorace transversim subquadrato, angulis anterioribus rectis, marginibus integris; superne breviter sparse flavo-setulosus, in elytris guttulis parvulis albidis ornatus. Long. $4\frac{1}{2}$–$5\frac{1}{2}$ millim.

Antennæ pitchy black, first and second joints subequal, extremity of the first visible from above, third joint rather longer than

second, ninth broader than those preceding it, transverse, tenth and eleventh forming a quite loosely articulated club. Head rather elongate, without elevations over the insertion of the antennæ; eyes rather large. Thorax broader than long, nearly straight at the sides, a little narrowed behind, the front rather deeply sinuated on each side, so that the front angles are prominent; the sides only slightly explanate; the surface very slightly impressed, quite dull; sculpture covered by a depressed dark squamosity, while along the middle there are some rather inconspicuous pallid, small, depressed scales, bordering the obscure impressions. Scutellum transverse. Elytra without elevations, and with no distinct sculpture, but with a dark depressed squamosity like that of the thorax, and mixed with this some flavescent scales, and also with some white scales forming eight or ten spots on the disk. Legs black; tarsi piceous. Under surface very dull, without definite sculpture, but with distant very minute pallid setæ.

Oyayama in Higo and Oyama in Sagami; seven examples.

Pseudotarphius.

This genus will be found described at length by Wollaston in the Trans. Ent. Soc. Lond. 1873, p. 1 *et seq.* It differs from *Glyphocryptus* by its convex form, more separated legs, shorter metasternum, and the obscurely margined, not explanate, sides of the thorax. The only species known is that described by Wollaston.

Pseudotarphius Lewisii.

Pseudotarphius Lewisii, *Woll. op. cit.* p. 4.

Nagasaki, Yuyama, and Hagi (*Mr. Hiller*).

Glyphocryptus, nov. gen.

Corpus latum, parum convexum, squamosum. Antennæ 10-articulatæ, clava uniarticulata, articulo basali condito. Prothorax fortiter transversus. Tibiæ simplices, tenues, margine externo squamoso; tarsi tenues, articulis tribus basalibus parvis, æqualibus.

This insect has more the appearance of a broad *Coxelus* than of any other genus; but it is at once distinguishable therefrom by the club of the antennæ, which shows only indistinct traces of a division into two joints, so that these organs may be called ten-jointed. There is no trace of antennal grooves on the thorax,

and those on the head are short and broad, the head being but little exserted and short; the eyes are quite visible on the under surface. All the coxæ are moderately separated, the metasternum rather short, though longer than in *Coxelus*.

Glyphocryptus brevicollis, n. sp.

Breviter suboblongus, parum convexus, opacus, rufescens, superne squamulis griseis, brevissimis, suberectis vestitus; hic inde subguttatus. Long. 3 millim.

Antennæ rather slender, the ninth joint not at all broader than the preceding, as long as broad, tenth forming a rather small oval club. Head short and broad, densely squamose; eyes scarcely visible from above. Thorax about twice as broad as long, bisinuate in front, the anterior angles acute and prominent, the medial lobe projecting nearly as far forwards as they, the sides rounded in front, abruptly constricted to form a very short space for the play of the front femora, the sculpture quite obscured by very short coarse erect scales; these extend to and project over the lateral margin, where they form a solid border. Elytra with their sculpture obscure, bearing rows of fuscous scales, and here and there with more pallid scales, giving a very obscurely spotted appearance; the outline not at all sinuate behind.

Yuyama in Kiushiu; two examples.

Labromimus, nov. gen.

Corpus suboblongum, parum convexum, dense squamosum, variegatum. Antennæ squamosæ, 11-articulatæ, clava minus abrupta, biarticulata. Prothorax fortiter transversus, parum emarginatus, marginibus explanato-elevatis. Tibiæ graciles, lineares, tarsi articulo basali quam sequens duplo longiore.

This genus may be placed near *Colobicus*, though not apparently very closely allied to any other yet characterized. The fact that the antennæ are clothed with variegated scales or setæ will greatly facilitate its recognition; their basal joint has only its extremity visible, the second short, conical, almost in fact triangular, the ninth slightly transverse, the tenth and eleventh forming a rather laxly articulated club, and not clothed with scales like the others; the eyes are large, and set with closely-placed short scales. The terminal joint of the maxillary palpus is thick, and is truncate at the apex; the antennal grooves are deep

and extend back nearly to the front margin of the thorax. All the coxæ moderately separated, the hinder pair are not very much more so than the others; the tibiæ slender, without spurs, and the basal joint of the hind tarsus as long as the two following together.

Labromimus variegatus, n. sp. (Plate III. fig. 3.)

Niger, densius squamosus, elytris variegatis, ad basin grisescentibus, pone medium fascia transversa macularum albidarum parvularum, et prope suturam maculis oblongis tomenti nigri; antennis pedibusque squamosis. Long. 4–5 millim.

Antennæ rather stout, clothed with fuscous and a few white scales, the tenth joint very strongly transverse. Head short and broad, densely clothed with grisescent scales, over the antennal insertion with broad, very low elevations. Thorax quite twice as broad as long, the sides rounded, the front angles not greatly prominent, the broad median lobe extending quite as far forwards as the angles; the surface rather uneven, being elevated along the middle, and bearing there four patches of intense black squamæ, two quite on the front margin, two, larger, on the disk; the surface rough and squamose, the lateral margin covered with projecting scales very closely set. Elytra at the base with some grisescent scales, which on the shoulder extend backwards so as to be there conspicuous, and with four patches of black tomentum; behind the middle with a row of small raised pallid spots, and just in front of these, touching the suture, two small patches of black raised scales; the surface appears to be crenate-striate, but the sculpture is obscured by the squamosity.

A good series of this species was procured at Oyama; and it was also met with at Kashiwagi, and in Yezo at Junsai.

Colobicus granulosus.

Oblongus, parum convexus, rufescens, prothorace elytrisque piceis, marginibus rufis; thorace elytrisque crebrius granulosis, tenuissime subtiliter pubescentibus; oculis longius setulosis. Long. $5\frac{1}{2}$ millim.

Thorax strongly transverse, anterior angles prominent, sides explanate, lateral margin closely and distinctly serrate; surface not punctate, but covered with rather coarse granules. Elytra covered with numerous granules like those of the thorax, but arranged in irregular longitudinal series; each granule bears a fine, short, upright hair; the lateral margins are also granulose,

giving a minutely denticulate appearance; each granule bears a hair projecting outwards. Under surface covered with obsolete granules.

This species differs from the following not only in sculpture, but in some of the more detailed structural characters. The clypeus is somewhat differently formed; it exhibits a slight incrassation on each side; the third joint of the antenna is not twice as long as the fourth; the eyes have fine, rather long hairs in place of minute scanty scales; and the antennal furrows are deeper and rather shorter. It is allied to *C. limbatus* and to *C. rugulosus*, Pasc.

Two examples were found at Nikko.

COLOBICUS EMARGINATUS, var.

Colobicus emarginatus, *Latr. Gen. Crust. et Ins.* ii. p. 10.

The Japanese specimens are broader and larger than the European, attaining 5 millim. in length; the sides of the thorax are more rounded, and less turned upwards, and the interstices between the series of punctures on the wing-cases are broader.

Five examples were found at Kashiwagi, in June.

ACOLOPHUS, nov. gen.

Corpus ovale, parvum, depressum. Tarsi antennæque debiles, hæ 11-articulatæ, clava biarticulata; oculi superne et inferne conspicui, capitis sulci antennarii elongati, arguti.

This genus need not be described at length, owing to its close relationship with *Colobicus*, from which it differs by the elongate antennary grooves which extend backwards beyond the eyes, while at the front angles of the thorax there is an extremely slight impression for the reception of the antennal club; this impression is merely a large indefinite hollow, but does not exist in *Colobicus*. The parts of the mouth, the tarsi, and antennæ are much more feeble than they are in *Colobicus*, the trophi being placed quite on the front part of the under surface of the head. The metasternum is elongate, the first ventral ring quite short, only about half as long as the metasternum. Under a high power the eyes are seen to be studded with excessively short minute asperities, which can scarcely be entitled to be called setæ.

ACOLOPHUS DEBILIS, n. sp.

Rufo-fuscus, opacus, parum sculpturatus, æqualis; corpore superne squamulis sparsis albidis vestito, margine laterali omnium subtilissime crenulato, densissime brevissimeque albido squamoso. Long. 2½ millim.

Antennæ small and slender, the basal joint quite concealed, the second slender though broader than those following, these minute and similar to one another; club rather long, very distinctly biarticulate. Head flat, broad; rather short; eyes quite conspicuous, not globular. Thorax strongly transverse, the sides evenly rounded in front and behind, the front angles prominent but only short, the front margin in the middle truncate, not lobed, the sides explanate; colours fuscous, reddish at sides; surface dull, without distinct sculpture, with a few fine pale depressed scales. Elytra dull, with very fine lines of sculpture, and with a few very small pale setæ; the lateral margins, as well as those of the thorax, extremely densely and finely crenulate, and fringed with excessively short, minute, contiguous white setæ.

Nikko, and on the Wada-toge in the month of August; three examples.

Cicones.

Cicones, *Curt. Brit. Ent.* iv. pl. 149; *Er. Ins. Deutsch.* iii. p. 272.

The characters by which this genus can be distinguished from *Synchita* will require reconsideration, as I am unable to find in the type of *Cicones*, viz. *Synchita variegata*, Hellw., the structure of the antennary grooves described by Erichson, and which is the only character of importance yet pointed out to distinguish the two. In *Cicones*, as represented by *C. variegata*, the antennary grooves are very short, and in *Synchita*, as represented by *S. juglandis*, they are still shorter, but of a similar character, and in other species they appear to be intermediate. Thus I only place the Japanese species in *Cicones* because of the close affinity of *C. ocellatus* with the European *C. variegatus*. *C. ditomoides* appears to be a very intermediate form; while the N.-American *S. parvula* is, so far as facies goes, quite a *Cicones*.

Cicones oculatus, n. sp.

Oblongo-ovalis, fuscus, antennis pedibusque rufis, elytris testaceis, fusco-signatis; oculis convexis. Long. 3 millim.

Antennæ with joints 3–9 small, the tenth joint forming a very large circular club. Thorax transverse, a little narrowed behind, the sides slightly curved at the front angles, which are scarcely prominent; fuscous black, the surface rather uneven, not distinctly sculptured, but variegate with some patches of cinereous setæ. Elytra pale red, with some irregular transverse black

marks, the largest of which is a large mark surrounding the scutellum; the black colour descends backwards along the suture, and connects two waved transverse marks, which, in a more or less indistinct manner, tend to be connected with the side margin by more pallid prolongations; their sculpture is indistinct, but they bear series of short white setæ.

This is very similar in size and shape to *C. variegatus*; but the thorax is more truncate in front and at the sides, the eyes are more globular, and the club of the antenna is twice as large.

Three examples were found: Nikko, Oct. 1880, and Wada-toge.

CICONES OBLONGUS, n. sp.

Oblongus, fuscus; antennis pedibusque rufis, his femoribus obscuris, elytris testaceis, fusco-signatis. Long. $3\frac{1}{2}$ millim.

This is closely allied to *C. oculatus*, but is of more elongate form, has the eyes a little less prominent, the front angles of the thorax more prominent, and the femora darker. It is equally close to the European *C. pictus*, Er.; but has the eyes a little more prominent, and on the underside of the head larger, the club of the antenna a little larger, and the surface of the thorax less uneven, with the sides less dilated.

Sapporo; two specimens.

CICONES NIVEUS, n. sp.

Breviter ovalis, antennis elytrisque testaceo-ferrugineis, his plus minusve nigro-guttatis, pedibus fusco-rufis, brevibus; corpore superne magis conspicue albido-setoso. Long. 2 millim.

The individuals are much smaller than those of *C. variegatus*, and have short antennæ and legs; the head is small, with the eyes only moderately large but prominent. The thorax is rather strongly transverse, with the sides but little rounded, and the front angles only slightly prominent; the surface is a little uneven and clothed with coarser and finer white setæ; these at the lateral margin are closely set, and so form a narrow continuous white border. Elytra with isolated black marks, placed as much at the sides as at the suture, the suture not black; the white setæ conspicuous, and with a few rather coarser ones placed in a serial manner amongst the rest.

Kashiwagi, 16th June; Chiuzenji, 22nd Aug. 1881; one example from each locality.

Although the two specimens differ considerably in the number and size of the black spots on the elytra, the species can be readily distinguished by the other characters, especially by the white margin of the sides of the thorax.

CICONES MINIMUS, n. sp.

Breviter ovalis, convexus, fuscus; pedibus fusco-rufis, elytris vage rufo-maculatis, setulis albidis erectis. Long. $1\frac{1}{2}$ millim.

Antennæ short, black. Thorax strongly transverse, but little rounded at the sides, the front angles not prominent, the surface quite dull, with a few griseous setæ, and a very short lateral fringe of densely-set white setæ. Elytra dull, dilute black, each with three rather vague red marks placed parallel with the suture; bearing numerous rather fine setæ of different colour, forming a rather scanty clothing, and also with a few short, coarse, erect, white setæ arranged serially. Legs feeble, sordid red, with the femora darker.

Although only a single example has been found, I think it represents a species distinct from *C. niveus*. It is probable that varieties of that species may be found with the elytra as extensively dark as in *C. minimus*; but the dark antennæ, and shorter, more convex form will probably prove sufficiently constant.

Yuyama, May 1881.

CICONES BITOMOIDES, n. sp.

Oblongus, parallelus, parum convexus, opacus, rufescens; thorace fusco; elytris nigro rufoque variegatis, seriebus regularibus squamarum erectarum pallidarum munitis. Long. $2\frac{1}{4}$–$2\frac{1}{2}$ millim.

Antennæ short, red; eyes small. Thorax as broad as elytra, straight at the sides, front angles only slightly produced, transversely convex, not impressed, margins armed with very short thick pale setæ or scales. Elytra red, behind the base with a broad lateral patch extending inwards to the suture, with a similar subapical mark extending also towards the suture, and more or less distinctly connected with the anterior dark mark by some dark colour along the suture, and armed with remarkably regular series of equidistant erect pallid scales. Legs clear red, short.

This species differs from the typical *Cicones* in having the sides of the thorax beneath vaguely impressed, and the coxæ less widely separate.

Nara, end of June; Suwa temple, Nagasaki, 17th April. Three examples.

Trionus, nov. gen.

Corpus depressum, sculpturatum. Antennæ basi tecta, 11-articulatæ, clava biarticulata; sulci antennarii elongati. Coxæ valde approximatæ, tibiæ lineares, ecalcaratæ; tarsi articulis tribus basalibus parvis. Abdominis segmento ventrali basali brevi. Ex affinitate generis *Bitomæ*, sed sulcis antennariis elongatis.

On the underside of the head the eye appears rather large, and along its inside margin there is a slender antennal furrow, which extends backwards beyond the eye, curving behind it, where a small fossa is found for the base of the club, the other side of the club reposing on the front margin of the prosternum. All the coxæ are more than usually approximate, and the first ventral plate is but little longer than that following it.

Although similar in appearance to *Bitoma*, this insect cannot be placed in it on account of the antennal grooves, as described above. I have a second species, closely allied to *Trionus opacus*, in my collection from East India.

Trionus opacus, n. sp.

Rufescens, elytris fuscis; opacus, depressus, rude sculpturatus; prothorace elytrisque costatis. Long. $2\frac{1}{4}$–3 millim.

Antennæ short, the ninth joint quite small. Head with raised rough granules. Thorax transverse, straight at the sides, and with the front angles a little prominent; the surface rough, and with some fine raised irregular ribs; the middle pair possessing some abbreviated pieces at the base connected with it, and being near the front abruptly constricted; the outer pair more regular, but slightly sinuate, and towards the front curving inwards; the side of the thorax is directed outwards, and is indistinctly crenate, without raised margin. The elytra have each three very strongly elevated fine ribs, and between them are transversely reticulate, the reticulations being the fine interstices of large punctures. Underside of head granular; ventral plates transversely impressed.

Nagasaki, Ichiuchi, and Yumamoto; eight examples.

Xuthia parallela, n. sp.

Fusca, opaca, antennis pedibusque rufis; prothorace oblongo, argute quadricostato; elytris fortiter punctatis subtiliter costatis. Long. $3\frac{1}{2}$ millim.

Club of antenna very loosely articulated. Head densely and finely granulose, quite dull, sides a little raised. Thorax oblong quadrate, being slightly longer than broad, with straight sides, granulose, quite dull, on each side with two costæ, in addition to the side margin, extending the whole length, the two inner a little convergent behind, between them with two short longitudinal elevations on the front margin. Elytra rather more than twice as long as the thorax, quite dull, with regular series of closely-placed angular punctures, the alternate interstices a little raised, the inner one more than the others, and all of the costæ more distinct near the extremity. Underside dull, coarsely punctate; ventral plates granulose.

The specimens vary somewhat in size and colour; frequently there may be seen an obscure reddish humeral mark.

A fine series was obtained in May 1881 at Hitoyoshi and Yuyama from Fungi on logs.

XUTHIA NIPONICA.

Xuthia niponica, *Lewis, Ann. Nat. Hist.* 1879, p. 462.

Angustula, subcylindrica, cinnamomea, opaca; prothorace oblongo, inæquali tantum subcostato; elytris seriatim fortiter punctatis, interstitiis alternis tantum obsoletissime elevatis. Long. $2\frac{1}{3}$ millim.

Antennæ short, with broad loosely articulated club, the ninth joint broader than those preceding it, the basal joint in part visible from the front; sides of the head evidently incrassate. Thorax about as broad as the elytra, a little longer than broad, very convex transversely, straight at the sides, just perceptibly narrowed behind, with a broad indefinite impression along the middle not extending to the base, outside this an irregular shallow impression extending the whole length; sides finely margined. Elytra with a series of closely-packed punctures; the second interstice from the suture very obscurely costate, the other alternate interstices scarcely perceptibly elevated; they are very slightly declivous obliquely before the apex.

This is an anomalous species, which will probably have to form a separate genus between *Xuthia* and *Ithris*; the antennæ are less covered at the base than in *Xuthia*, the clypeus being smaller and the form of the mouth more approximating to the *Colydium*-type; the metasternum, too, is more elongate.

Nagasaki; a single example in Mr. Lewis' bungalow, August 1868.

Ithris sculpturata, n. sp. (Plate III. fig. 4.)

Rufo-fusca, antennis pedibusque rufis, elytris fuscis; prothorace quadricostato; elytris haud elongatis, posterius oblique truncatis, argute costatis, interstitiis fortiter sculpturatis. Long. $2\frac{1}{2}$–3 millim.

Antennæ short, clear red, with loosely articulated three-jointed club. Sides of head strongly elevated. Vertex granulose; clypeus subtuberculate, not granulose. Thorax nearly as broad as the elytra, about as long as broad, only very slightly curved at the sides; the surface coarsely granulose, and adorned with four longitudinal ribs; the ribs are connected in front by an elevation of the anterior margin, the inner pair are flexuous, the outer straight; the sides are also strongly margined, the margin not being crenate. The elytra have each four costæ, and besides these the suture and outer margin are somewhat costate; the second costa from the suture is the most elevated, and diverges behind somewhat towards the side, joining the lateral margin before the apex, and defining externally the declivous apex; the grooves between these ribs bear two rows of deep punctures giving rise to a beautifully sculptured appearance. Ventral plates crenate; epipleuræ near extremity deeply crenate.

Oyayama, June 1st, 1881; three examples.

Gempylodes Lewisii, n. sp. (Plate III. fig. 5.)

Angustus, perelongatus, cylindricus, niger, opacus, antennis pedibusque rufis; prothorace canaliculato, basi tri-impresso; elytris subcostatis. Long. 7–8, lat. $\frac{3}{4}$ millim.

Antennæ broad, broader from the third to the tenth joint, so that the first of these being as long as broad, the latter is strongly transverse. Thorax very elongate, narrowed from behind the middle to near the base, at which it is again a little broader; it is only sparingly and finely punctate, but is quite dull, and has on the middle a conspicuous channel occupying the greater part of its length, and at the base three large impressions. Elytra almost without sculpture, except that the alternate interstices are a little elevated; these elevations become well marked at the extremity, which is obliquely declivous; the actual apex is emarginate in the middle, and on the middle of each side of the emargination there is a small tooth.

Yuyama, in Higo; forty examples.

Cylindromicrus, nov. gen.

Corpus angustum, cylindricum. Antennæ breves 11-articulatæ, articulo basali haud condito, clava brevi, lata, biarticulata. Tibiæ calcaratæ; tarsi articulo basali elongato.

The head is short and broad, deflexed, provided beneath with elongate antennal grooves, which, owing to a considerable extension inwards of the eye, are convergent behind. The front coxæ are contiguous, subexserted, a small raised process of the prosternum existing behind them; middle coxæ separated by a far from narrow process of the mesosternum. Metasternum very elongate; posterior coxæ not widely distant; first ventral plate much longer than the following. Tibiæ but little angulate at the apex, each with a rather long slender spur; tarsi filiform, basal joint of the posterior nearly as long as the other three together.

This is allied to the genus *Metopiestes*, Pascoe, about whose position its describer was probably mistaken. The present genus at any rate must be assigned to the vicinity of *Colydium*, not to the Bothriderini, where *Metopiestes* was located, but which in the Munich Catalogue stands near *Colydium*. It differs from *Metopiestes* by the slender form, and undilated femora; by its tibiæ, of which even the front pair are but little angulate externally, with a comparatively feeble spur; and by the less separated hind legs. In Horn's arrangement of the family both *Metopiestes* and *Cylindromicrus* would be placed in the group Deretaphrini, on account of the contiguity of the front coxæ.

Cylindromicrus gracilis, n. sp. (Plate III. fig. 6.)

Elongatus, angustulus, cylindricus, castaneus, parum nitidus, fronte dense tomentosa; elytris costis tenuibus elevatis. Long. $3\frac{1}{2}$ millim.

Head furnished on the anterior part with a dense erect pile, such as is seen in some species of Tomicidæ in a similar position. Thorax elongate, a little narrowed behind; lateral margin extremely fine; surface dull, bearing a peculiar moderately close sculpture of elongate punctures or scratches; in in front the scutellum with two obscure longitudinal elevations connected in a curve behind. Elytra elongate, somewhat obliquely declivous before the somewhat prolonged apex, each with five parallel fine sharply elevated costæ, but without other sculpture; the third of these costæ is strongly elevated at the apex, and curves round

and connects with the suture, the intermediate costa ceasing abruptly a little behind the commencement of the declivity.

Oyayama, near Kumamoto; two examples.

TEREDOLÆMUS, nov. gen.

Corpus subcylindricum. Antennæ 10-articulatæ, articulo basali libero, clava magna rotundata uniarticulata. Tibiæ extus ad apicem vix angulatæ, calcaribus minutis; tarsi parum elongati, articulo basali tibiæ apicem haud superante. Coxæ anteriores contiguæ, intermediæ et posteriores acuminatæ; abdomen segmento primo ventrali sequente conspicue longiore.

This genus is allied to *Teredus* and to *Oxylæmus*; from the former it differs by the structure of the antennæ, and the shorter form, the prosternum in front of the coxæ being but little elongate: in the structure of the antennæ it agrees tolerably with *Oxylæmus*, from which it differs in a number of characters, such as the simple tibiæ, the uncompressed prosternum, and the obsolete antennal furrows. One of the species has been already described by Mr. Lewis as a *Teredus*; but he remarked that the species would probably require generic separation on account of the antennal structure.

TEREDOLÆMUS POLITUS. (Plate III. fig. 7.)

Teredus politus, *Lewis, Ann. Nat. Hist.* 1879, p. 462.

Konose in Higo; seven specimens.

TEREDOLÆMUS GUTTATUS, n. sp.

Cylindricus, parum elongatus, nitidus, niger; elytris ad apicem, antennis pedibusque rufis; subtiliter punctatus. Long. $2\frac{3}{4}$–3 millim.

Thorax about as long as broad, sparingly and finely punctate. Elytra with rows of fine punctures, becoming obsolete at the extremity; interstices impunctate, each impressed near the suture just before the apex, and the apical portion furnished with a very few elongate extremely fine setæ.

The individuals of this species are smaller than those of *T. politus*; and are readily distinguished by the large red mark and the finer punctuation. The species probably preys on some member of the Tomicidæ, to some of which it is similar in form; and it is curious that the apex of the body is also like many *Xylebori* in form.

A good series of this species was secured at Kashiwagi in the month of June, and it was also met with during the previous month at Yuyama.

Leptoglyphus, nov. gen.

Antennæ 9-articulatæ, clava maxima, inarticulata; tibiæ extus angulatæ; coxæ posteriores valde distantes.

This genus, allied to *Bothrideres*, is distinguished by the peculiar structure of its antennæ; their basal joint is short and very thick, but quite exposed, the second joint very short, transverse, angulated above, third joint slender, 4–8 small; terminal joint very large, subtriangular, with the apex of the triangle articulated to the eighth joint, and the free base of the triangle together with the angles somewhat curved, quite as broad as the length of the joint. The eyes are large, convex, finely granulate; the palpi small and slender; the front coxæ moderately distant, the prosternum between them very distinctly divided. The metasternum is very elongate, the first ventral segment three times as long as the second; the front tibiæ are very strongly angulate at the apex externally, the middle more slightly so, the hinder almost simple.

Leptoglyphus vittatus, n. sp.

Parum elongatus, haud depressus, niger, opacus; antennis pedibusque rufis, elytris late longitudinaliter rufo-bivittatis, argute costatis. Long. $3\frac{1}{2}$ millim.

Head small, only about half as broad as the thorax, densely punctate. Eyes convex. Thorax much narrower than the elytra, about as long as broad, the sides rather finely margined, and forming an obtuse angle a little in front of the middle, the surface coarsely and closely punctate, obscurely depressed along the middle, the depression broadest and most distinct at the base. Elytra with the upper part chiefly red, but the deflexed sides black, and the suture also of this colour, each with three acutely elevated costæ, and on each side of each costa a series of very fine punctures.

Hitoyoshi, 17th May, 1881; a single example.

Erotylathris costatus, n. sp. (Plate III. fig. 8.)

Piceus, opacus, prothorace quadricostato, costis posterius a fissura transversa profunde divisis; elytris sulcatis, interstitiis argute elevatis et subtilissime crenatis. Long. 4–5 millim.

Thorax a good deal narrowed behind, much longer than broad, traversed by two coarse, much elevated, longitudinal ribs on each side of the middle; and the side has a fine raised margin, parallel

to which is another fine elevation that joins the outer of the two coarse ribs some distance in front of the base, and just in front of this junction is connected with the fine lateral margin by a small elevation that causes the side of the thorax to appear slightly denticulate; in front of the base there is a very deep transverse cavity that divides the two middle costæ, but the interruption is only brief, as the extremities of the divided costæ project somewhat over the cavity. The elytra bear very broad deep grooves separated by very regular narrow interstices, the summits of which are minutely crenate and furnished with excessively minute setæ; the grooves bear two series of punctures which are so nearly joined that, viewed in a particular direction, they appear as a single series of large punctures or impressions. Body beneath closely and coarsely punctate, quite dull.

This is no doubt rather closely allied to *Machlotes porcatus*, Pasc.; but it differs from the excellent description given of that species in the sculpture of the under surface, and in some of the details of the peculiar thoracic sculpture.

Rare. Nara and Nishimura on the main island, and Sapporo in Yezo. In all four examples.

DASTARCUS LONGULUS, n. sp. (Plate III. fig. 9.)

Oblongo-ovalis, elongatus; prothorace vix transverso, elytris angustiore, plagiatim fusco-squamoso; elytris costatis, nigro-griseoque densius squamosis. Long. 6–11 millim.

Although very similar to *D. porosus*, this is readily distinguished by its more elongate form, and particularly by the less transverse thorax, this being just about as long as it is broad at the base. The individuals vary much in size and a good deal in the coloration of the scales; the thorax is a little narrowed behind, and has the sides very densely squamose; there are also two lines of scales along the middle, a more indistinct line near the lateral margin, and a tubercular patch between the latter and the middle. On each elytron there are four series of squamigerous costæ, the scales of each being very dense, and variegate in a somewhat irregular manner, the paler scales being most conspicuous at the base and apex, and forming an irregular fascia behind the middle.

Nine examples were met with at Konose in Higo, May 17th, 1881. Probably the species may not extend northward out of Kiushiu

Pycnomerus vilis, n. sp.

Oblongus, angustulus, nitidus, piceus; prothorace crebre fortiter punctato; elytris fortiter crenato-punctatis, interstitiis angustis impunctatis. Long. $3\frac{1}{2}$ millim.

Thorax longer than broad, a little narrowed behind, shining black or piceous, moderately closely punctured with rather coarse punctures that are not evenly distributed, so that the interstices in some places are broader, and there is an irregular smooth space along the middle. Elytra with very regular series of coarse elongate punctures, the interval between each two punctures being indistinct, while the interstices between the series are distinct and regular, and are nearly as broad as the series; at the extremity there is a small plica preceded by a depression. Under surface shining, coarsely but sparingly punctate; last ventral deeply impressed.

Both this species and *P. sculpturatus* belong to *Penthelispa*, Pascoe, which I cannot at present regard as more than a subgenus, it being distinguished from *Pycnomerus* only by the club of the antennæ being distinctly divided into two joints.

This species was found in several localities on the main island and Kiushiu, and a single example was met with at Junsai in Yezo.

Pycnomerus sculpturatus, n. sp.

Oblongus, angustulus, opacus, piceus; prothorace dense fortiter punctato, disco minus extense bi-impresso; elytris fortiter crenato-punctatis, interstitiis angustissimis, punctatis. Long. $3\frac{1}{2}$ millim.

Similar in size and form to the preceding species, this is very distinct by its sculpture; it has, too, shorter and thicker antennæ. The head is deeply bifoveate; the thorax strongly margined at the sides, much narrowed behind, coarsely and very densely punctured, with two indistinct small impressions on the middle, and just behind them a minute shining space. Elytra with very regular series of coarse deep punctures, the intervals between the series very narrow, not more than half as broad as the series, but distinctly punctured. Under surface rather closely, coarsely punctured, but slightly shining; last ventral deeply depressed.

Tonosawa, near Miyanoshita. Three examples were found under bark of fir.

PHILOTHERMUS DEPRESSUS, n. sp.

Depressus, rufo-castaneus, nitidus; prothorace transverso, parce punctato, margine laterali subtilissime setoso; elytris seriatim punctatis, ad apicem lævigatis. Long. 2 millim.

Antennæ with the first joint broad, the intermediate joints slender, the ninth larger than those preceding and evidently transverse, the tenth and eleventh forming an elongate club. Head small, deeply immersed in the thorax. Eyes very small and prominent. Thorax a good deal broader than long, the sides straight, except in front, where they are greatly curved inwards to the front angles, which are greatly depressed; the lateral margin strongly raised behind, and furnished with some excessively fine outstanding setæ, which, however, are wanting on the anterior part; the surface quite shining, and sparingly but distinctly punctate. Scutellum transverse. Elytra with regular series of punctures which are quite distinct at the base, but disappear before the apex; the suture depressed behind; and furnished with an impressed stria, which gradually disappears as it extends forwards.

Found on the main island and Yezo, in eight examples; Miyanoshita, Hakone, Junsai, and Sapporo.

ECTOMICRUS, nov. gen.

Corpus breve, superne plus minusve setosum. Antennæ 10-articulatæ, clava elongata, apicem versus annulata. Pedes anteriores et intermedii parum, posteriores mediocriter, distantes.

Although the insects for which I make this genus are very different in facies from *Cerylon*, they are nevertheless closely allied thereto, but are well distinguished by the less widely distant coxæ. The characters of the genus are taken from *Ectomicrus rugicollis*; *E. pubens* will, I think, have to form a distinct genus between *Ectomicrus* and *Cerylon*, as it differs in certain characters, as I shall mention below. In *Ectomicrus rugicollis* the club of the antenna is elongate and acuminate, its outer half being pubescent, and the pubescence so arranged as to give rise to an obscure appearance of the club being three-jointed. The eyes are small but very prominent; the fine lateral margin of the thorax is crenate; the front coxæ are separated only by a small space, the prosternal process being reflexed immediately behind them; the metasternum is but little longer than the first

ventral segment, this latter as long as the two following together. The legs are rather slender, the tibiæ broader towards the extremity, but rounded off so as to become narrower at the apex. *E. pubens* is more of the form of *Cerylon*, but has a shorter first ventral segment and shorter legs, and its antennæ have a less elongate, only very obscurely annulate club. The genus is also represented in Ceylon; and the species found there confirm the importance I have attached to the greater approximation of the front coxæ as a differential character from *Cerylon* *; and they have the prosternal process received into a more or less distinct cavity of the mesosternum.

Ectomicrus rugicollis, n. sp.

Rufo-piceus, antennis pedibusque rufis, superne setulis tenuissimis brevibus erectis parcius vestitis; prothorace densissime grosse punctato, interstitiis angustis; elytris fortiter seriatim punctatis. Long. $2\frac{1}{2}$ millim.

Antennæ as long as head and thorax; second joint rather slender, longer than broad, a little longer than the third joint; joints 4–10 differing little from one another. Thorax transverse, a little

* The following description of another genus of Cerylonini from the Andaman Islands adds an insect of peculiar facies to the little group of genera constituting this division.

Pachylon, nov. gen.

Corpus oblongum, subdepressum, nitidum. Antennæ 10-articulatæ, parum elongatæ, crassæ, articulo basali crassissimo, clava parum abrupta, elongata, acuminata. Palpi maxillares articulo ultimo minuto, acuminato, labiales perapproximati, articulo penultimo valde incrassato. Coxæ anteriores parum distantes, prosterni processus apice reflexo. Coxæ intermediæ sat, posteriores valde, distantes. Abdomen segmento primo basali magno, sequentibus tribus fere majore. Tibiæ ad apicem paullo latiores, sed vix angulatæ; tarsi articulis basalibus brevibus subtus setosis.

Although very dissimilar in appearance to *Cerylon*, this genus is closely allied thereto, but can be distinguished by the different shape of the tibiæ, and by the more approximate front coxæ, the prosternal process also being bent upwards immediately behind the coxæ, instead of becoming broader and flat.

Pachylon Gorhami, n. sp.

Oblongus, nitidus, niger, antennis pedibusque piceis; prothorace amplo, transverso, lateribus valde rotundatis, versus latera fortiter punctato, sed ad marginem ipsum impunctato; scutello lato; elytris regulariter seriatim punctatis, interstitiis latis, impunctatis. Long. 5–6 millim.

I have named this remarkable Colydiid in honour of the distinguished naturalist, the Rev. H. S. Gorham, to whose kindness I am indebted for my specimens.

Andaman Islands.

curved at the sides, the front angles scarely produced, but the sides distinctly narrowed towards them; the lateral margin very fine, irregular, its outline being apparently broken by the coarse punctures; the whole surface covered with very large, moderately deep punctures, placed so close together that the interstices are narrow and thread-like. Elytra closely covered with series of coarse punctures, the punctures occupying a larger space than do the interstices.

Subashiri, 4th May, 1880, and Oyayama. One example from each locality.

Ectomicrus pubens, n. sp.

Rufo-castaneus, nitidus, pube laxa parce vestitus; prothorace transversim quadrato, sat crebre subtiliter punctato; elytris seriatim punctatis, punctis apicem versus obsoletescentibus. Long. $2\frac{1}{3}$ millim.

First joint of antenna very broad, behind flattened so as to have a quadrate appearance; second joint slender, third short but distinctly longer than the minute joints following it. Head rather broad, though much narrower than the thorax, only very sparingly punctured. Thorax quite as broad as the elytra, very slightly curved at the sides, except at the front angles, where the curvature is more distinct; the lateral margin very distinct, obsoletely crenate; the surface somewhat sparingly punctate. Scutellum broad. Elytra short, with series of punctures that are rather coarse at the base, but become obsolete at the apex; the suture depressed behind, and furnished with a fine stria which disappears by passing gradually into the first series of punctures.

This species has been met with in a few examples only both on Kiushiu and the main island: Hitoyoshi, Oyayama, Yuyama, and Miyanoshita.

Cerylon crassipes, n. sp.

Oblongum, ferrugineum, nitidum; prothorace subquadrato, basin versus angustato, fortiter punctato; elytris striatis, striis apicem versus obsoletis. Long. 2 millim.

Antennæ stout. Thorax about as long as broad, the sides straight but distinctly narrowed behind, the hind angles rectangular; the surface rather coarsely and closely punctate, the base a little elevated in the middle. Elytra with rather deep striæ, which become obsolete at the extremity; the interstices almost impunctate. Tibiæ very stout.

Although similar to *C. angustatum* and to *C. deplanatum*, this is

readily distinguished by the thorax being a little narrowed behind and by the very thick legs. Although in the small series before me these characters show considerable variation, yet I have not been able to satisfy myself that there is more than one species; though when more examples have been accumulated, such may prove to be the case.

This is apparently rare, only one or two examples having been procured at each of the localities where it was met with. Typical examples were obtained at Oyayama in Kiushiu, and at Miyanoshita and Nikko on the main island; a variety at Yuyama and Kashiwagi, and a very aberrant form with slender legs at Nikko and Oyayama.

Cerylon minimum, n. sp.

Oblongum, testaceo-ferrugineum, depressum, nitidulum; prothorace oblongo basin versus vix angustato, sat fortiter punctato, elytris subtiliter striatis. Long. $1\frac{1}{3}$ millim.

Antennæ, except the club, rather slender. Thorax slightly longer than broad, only very slightly narrowed behind, not impressed at the base. Elytra finely striate, interstices impunctate. Legs rather stout; tibiæ short.

Although very closely allied to *C. crassipes*, I think, so far as I can judge from inspection of one example, that this is really distinct, and can be distinguished by the smaller size and much more slender antennæ.

Sapporo, Yezo; one example.

Cerylon curticolle, n. sp.

Oblongum, ferrugineum, nitidum; prothorace transverso, fortiter punctato, elytris fortius striatis. Long. $1\frac{1}{2}$ millim.

Antennæ rather slender, but with large club. Thorax strongly transverse, coarsely punctate, at the base a very small but distinct impression on each side. Elytra more deeply striate than usual, the striæ obsolete at the extremity. Legs slender. Prosternal process broad.

Although only one example has been procured of this species, I have no doubt it will be readily identified by the transverse thorax.

Ichiuchi, 1st May, 1881.

CAUTOMUS, nov. gen.

Caput minutum, palpis exsertis. Antennæ 10-articulatæ, clava elongata, quasi divisa. Prosternum longitudinaliter compresso-carinatum. Pedes posteriores sat distantes.

This genus is well distinguished by the minute head, in strong contrast with the ample thorax, and the palpi placed at the front of the mouth and more than usually exserted, as well as by the peculiar carination of the prosternum along the middle; this carina extends the whole length of the prosternum, and projects scarcely at all behind the coxæ, its extremity replacing the prosternal process. All the femora are rather large, the anterior pair being decidedly larger than the others. The middle coxæ are nearly contiguous, the metasternum rather short; the first ventral plate in the middle nearly as long as the two following together. The tibiæ are somewhat dilated externally, so as to be slightly angulate some distance above the apex.

CAUTOMUS HYSTRICULUS, n. sp. (Plate III. fig. 10.)

Fusco-rufus, opacus, setulis truncatis, erectis, pallidis conspicue vestitus; prothorace densissime rugoso-punctato; elytris dense obsolete sculpturatis. Long. 2 millim.

Antennæ with elongate acuminate club, which, owing to the apical half being pubescent, appears to be divided across the middle. Thorax strongly transverse, the sides greatly narrowed towards the deflexed front angles; the surface very dull, owing to extremely dense punctuations, the interstices of which can scarcely be detected; the lateral margin undulate behind, the base with a short indistinct excision at the angle. Elytra with a dense but very indefinite sculpture, the interstices of which are to be distinguished as a series of very minute, irregular, shining spaces, and provided with perfectly regular series of short, stiff, upright setæ. The thorax also bears similar setæ, but they are less distinct on it except at the margins.

This was met with in fifteen examples at Tagami, near Nagasaki, in the spring of the year 1881. This and the next species were taken in the centre of a large rotten fir, which measured many feet in circumference, and was probably more than 300 years old.

THYRODERUS, nov. gen.

Corpus minutum, convexum, fortiter sculpturatum. Antennæ 8-articulatæ, clava rotundata, uniarticulata. Prosternum utrinque maxime excavatum.

Head retractile, palpi small, slender, terminal joint extremely slender, acuminate; eyes minute, but very prominent. Prosternum with a chin-piece in the middle, to which the retracted head is quite closely applied, so that the mouth is entirely covered; the whole of the side of the thorax beneath, from near the front to the hind angle, is excavated, forming a very large cavity in which the retracted antenna can move freely; this excavation extends to the upper surface of the thorax, which bears two quite transparent spaces, admitting light to the interior of the antennal cave. The minute front coxæ are a little separated by a small process little dissimilar from that of *Cerylon*. Middle coxæ more widely separated than the anterior; posterior widely distant as in *Cerylon*; first ventral segment large, as long in the middle as the three following together, division between the fourth and fifth segments rather obscure. Tibiæ simple; tarsi with the three basal joints minute.

The extraordinary structure of the thorax is sufficient to distinguish this insect from all others we yet know, the whole of each side of the thorax forming a cave, lighted by two windows above, in which the antennæ can move about. Except for this peculiarity, I do not see anything which should militate against the placing of the genus in the Cerylonini, for although the antennæ are apparently only eight-jointed, yet their structure is similar to that of *Cerylon*, except for the disappearance of two of the small intermediate joints, a character which is perhaps not of very great importance.

Thyroderus porcatus, n. sp. (Plate III. fig. 11.)

Anguste oblongus, convexus, fusco-rufus, opacus, dense punctatus, setulis brevissimis parce adspersus; prothorace utrinque prope marginem lateralem oblique bi-impresso; antennis pedibusque rufo-testaceis. Long. $1\frac{1}{3}$ millim.

Antennæ short, basal joint large, second smaller, almost spherical, the following five all minute, the eighth forming a rather large, shortly oval club. Head deflexed; eyes minute. Thorax rather broader than long, a little rounded at the sides, and a good deal narrowed in front, very convex transversely; rough, being extremely densely punctured, and bearing very minute upright setæ, with a broad lateral margin, near which are two curvate impressions, the posterior being the longer, and extending nearly to the base of the thorax. Elytra coarsely

and very densely punctate, the punctures in series, and the alternate interstices elevated, so as to form very fine, rather in distinct costæ, and sparingly clothed with erect, rather coarse, very short, pale setæ.

A good series was secured, in the same tree as *Cautomus hystriculus*, near Nagasaki, 25th March, 1881.

DESCRIPTION OF PLATE III.

Fig. 1. *Neotrichus hispidus*, Sharp.
2. *Sympanotus pictus*, Sharp.
3. *Labromimus variegatus*, Sharp.
4. *Ithris sculpturata*, Sharp.
5. *Gempylodes Lewisi*, Sharp.
6. *Cylindromicrus gracilis*, Sharp.
Fig. 7. *Teredolæmus politus*, Lewis.
8. *Erotylathris costatus*, Sharp.
9. *Dastarcus longulus*, Sharp.
10. *Cautomus hystriculus*, Sharp.
11. *Thyroderus porcatus*, Sharp.

Notes on the Antennæ of the Honey-Bee. By T. J. Briant. (Communicated by B. Daydon Jackson, Sec. Lin. Soc.)

[Read 15th November, 1883.]

The antennæ of the Honey-Bee (worker) are inserted quite close together, immediately above the upper margin of the clypeus (fig. 1). They consist of a pair of jointed cylindrical organs of two distinct parts, called respectively the scape and the flagellum. The scape is united to the cranium by a hemispherical cup, to which it is joined by a short constricted peduncle (fig. 2 *a*). At its anterior end it is united to the flagellum, and is normally at right angles to it.

The antenna moves as a whole upon a point or fulcrum formed by the interlocking of the peg or process (*a* in fig. 3) with the notch in the cup (*b* in fig. 2). This process arises on the inner or medial side of an arch which bridges over the antennary fossa to near its top on the outer edge, and the process is thus nearly in the centre of the fossa. The movements of the antenna are controlled by three muscles:—(1) a muscle inserted into the outer margin of the basal cup, which moves it outwards (figs. 3 & 4, *b*); (2) a muscle inserted into the upper and inner margin, which moves it upwards and inwards (*c*); and (3) a muscle inserted in the lower margin, which opposes the other muscles and lowers the antenna (*d*). These muscles arise from the internal skeletal parts of the cranium, which cannot conveniently be described without entering into details of the endocranium.

The scape is rather less than half the length of the flagellum. The larger portion, or shaft, has its anterior end cut off obliquely and so allows of the flagellum bending upon it by a simple motion of flexion and extension. These motions are produced, one by a muscle arising from the lower inner wall, and inserted into the lower side of the second segment of the antenna (fig. 2 *d*); the other by a muscle arising from the upper inner wall, and inserted into the upper side of the same segment (fig. 2 *e*).

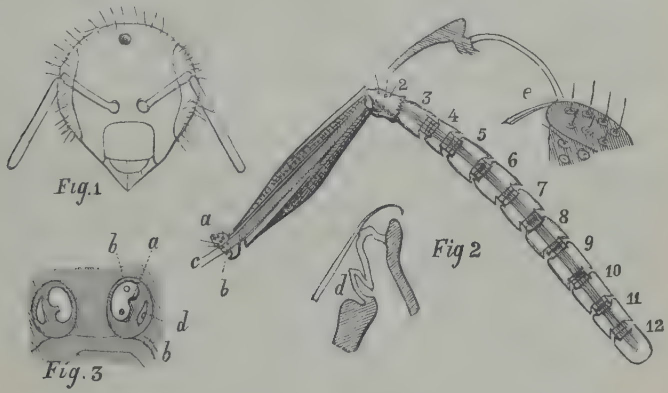


Fig. 1. Outline of head of Bee, showing position of antennæ.
Fig. 2. Sectional view of antenna; with enlargements of upper and under part of the articulation to show the insertion of the muscles *e* and *d*; *c*, nerve.
Fig. 3. The antennary fossæ from below. The dots *b* and *d* show position of insertion of muscle; *a* is the peg or process upon which the antenna moves.

The segments forming the flagellum are alike in form and vary but slightly in size, the most distant one (the 12th of the antenna) being twice, and the fifth being about $2\frac{1}{2}$ times longer than broad. The fourth is peculiarly short, not being more than two thirds of its breadth, and moreover tapers somewhat towards its posterior end. The third continues the tapering, but in length is twice its mean breadth. The second is slightly bent, and bears on each side the swelling or knob upon which the flagellum hinges with the scape.

The joints connecting together the segments numbered in fig. 2 as 4 to 12 are all very similar in plan, and consist essentially of a convexity on the posterior end of one segment fitting into the concavity of the anterior end of the preceding segment.

The ends are as it were pierced with a hole of comparatively considerable size, and the edge of each hole is bent inwards. A band of elastic tissue runs from the inner edge of the bent-in part of one hole to the inner edge of the bent-in part of the other, and thus connects the parts together by a joint which, while allowing of movement in every direction, yet does not in any way compress the tube. The segments 2 and 3 do not appear to be moveable upon one another.

I do not find any muscles regulating the movements of these segments; nor can I discover, from anything I have at present seen, that the Bee ever voluntarily moves them upon one another.

The offices these organs fill in the economy of bee-life, evidently all-important to the Bee, is a matter of much mystery; it seems to be scarcely a matter of dispute, for no one appears to have settled the question to his own satisfaction; but a close examination of the flagellum discloses certain hairs and pits, found chiefly on the front of the antenna, which must be accounted for in any theory which may be put forward. They were noticed for the first time by Dr. J. Braxton Hicks; and his communications are to be found in vol. xxii. of the 'Transactions of the Linnean Society,' pp. 148 and 388. He seems, however, to have confined his attention to the markings appearing on segments in the middle of the flagellum.

Fig 4.

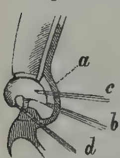


Fig 5.

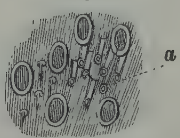


Fig. 6.

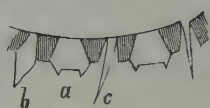


Fig. 4. Sectional view of the articulation of antenna: *a*, bridge; *b*, *c*, and *d* indicate the position of the insertion of the muscles.

Fig. 5. Part of a segment of antenna near the end, showing oval markings; *a*, the group of openings leading to the tubular structure shown in fig. 8, *a*.

Fig. 6. Diagrammatic section of the structure shown in fig. 5.

The cup at the base of the scape is furnished with hairs which spring apparently from the bottom of pits, and radiate in all directions. Similar hairs are also to be found on the second segment. From not finding any nerve-structure intimately connected with these hairs, and also from finding hairs of a similar description in some parts of the sting, I conjecture that their office is merely mechanical, and that they serve to keep the

joint in its proper place. The membrane which joins the scape with the second segment has some very minute yellow dots upon it, which terminate in short sharp points or hairs. The markings on other segments are described by Dr. Hicks in these words :—"Every structure consists (viewed from above) of round transparent spots about $\frac{1}{1760}$ inch in diameter, but on a side view they are seen to be depressions of the surface, the internal wall being perforated, with a thin membrane closing in the perforation, which is probably the external layer of the antennal wall continued over it." This is quite accurate as regards those segments in the middle portion of the flagellum, but as they approach the anterior end, and especially in the last segment, they are much more complicated. On the end segment there seem to be five distinct sorts of structures.

The first, when viewed from above, appear as openings in the wall of the antenna, which, on a broken edge, are seen to be covered by a membrane. Upon focusing down to the general surface of the antenna, this suddenly opens into a wider space surrounded by a ring of dark dots; and on continuing the focusing, the opening again contracts to a size smaller than the opening on the outer wall. If, however, a fresh antenna be examined, under a $\frac{1}{2}$-inch object-glass, without any preparation and with light directed along it from the anterior end, the structure appears as in fig. 5 (sectional view *a*, fig. 6). The upper membrane is supported upon a rim, and presents somewhat the appearance of the lid of an oval hunting-watch, the small glass representing the upper membrane.

The second structure is found interspersed amongst those just described, and consists of smaller openings, which, instead of being closed in at the top, are drawn out into a pointed hair (*b*, fig. 6).

The third structure consists of hairs springing from the base of still smaller pits (*c*, fig. 6).

The foregoing coincide very closely with some of the structures described by Dr. Hicks in other insects, the first being similar to that of the antenna of *Andrena fulva*; but he does not give any description of its appearance by direct light. The second and third are similar to structures found by him in the antenna of *Geotrupes stercorarius*. I give a diagrammatic figure of them in section in fig. 6.

The fourth structure is found only on a ridge on the end of the last segment, fig. 7. The appearance is that of hairs sunk in pits

as before; but they are distinctly slighter in build and are bent at right angles at about half their length, the hooks of the hairs on either side being directed towards each other. It must be remembered that the Bee invariably uses this extreme tip in touching anything; and that it touches its fellow Bee upon the front of the antenna. It is also to be noticed that the wall of the antenna becomes considerably thinner at the extreme tip.

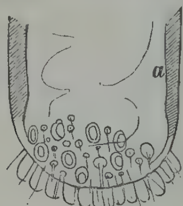


Fig. 7

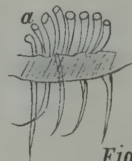


Fig. 8

Fig. 7. Section of apical segment of antenna, showing the thinning of the walls and the hooked terminal hairs: *a*, granulous nerve-structure.

Fig. 8. Section of fragment of antenna, showing, *a*, tube-like organs seen at *a*, fig. 5.

The fifth structure is more difficult to make out. Within, the segments are lined with granular nerve-structure (fig. 7, *a*); and in certain parts are to be found imbedded in this nervous matter some tubular, slightly conical forms (fig. 8, *a*), which arise from the inner surface of the antenna. They are very similar to the stethoscope-like organs described by Sir John Lubbock in the antenna of *Myrmica ruginodis* *, excepting that there is no tube connecting them with the walls of the antenna, with which they are in immediate contact, and through which they communicate with the outside, by pores collected into a small group (fig. 5, *b*), and found near the articulation.

It is probable that the hooked hairs at the end of the antenna are active sense-organs, and that the other organs are passive. That some are for smell there can be no doubt; but as there remain yet to be described several organs of the same character in various parts of the tongue and mouth, it is perhaps premature to attempt to settle the special offices of those of the antenna.

P.S.—Since the above was read to the Society, I have, through the kindness of Dr. Murie, had my attention directed to a paper by Dr. Paul Schiemenz in the 'Zeitschrift für Wissenschaftliche Zoologie,' Band xxxviii. 1883, p. 71, in which he gives a description of the foregoing structures, and refers to them as touch- and smell-organs.

* 'Ants, Bees, and Wasps,' 1882, p. 227; and Monthly Micros. Journ. 1877, p. 131.

On the *Cerithiopsides* from the Eastern Side of the North Atlantic, with three new Species from Madeira. By the Rev. R. Boog Watson, B.A., F.R.S.E., F.L.S., Hon. Fellow of the Naturwissenschaftlich Verein Lüneburg.

[Read 15th January, 1885.]

(Plate IV.)

The whole of the Madeiran Cerithiopsides, except *C. Metaxæ*, Chiaje, so much resemble the large elongated variety of *C. tubercularis*, Mont., that for their determination the points of difference alone require to be noted; but for the sake of comparison, and to remove confusion between the little-known species of the group, I add here some notes of all the species found in the North-east Atlantic, none of which, so far as I know, have been adequately figured. On the Mediterranean species I do not enter, in the hope of speedily seeing them fully described and figured by the Marquis de Monterosato, to whose kindness I am indebted for the knowledge of them, and who has already given some valuable notes on the group in the 'Journal de Conchyliologie,' 1874, p. 274, 1877, p. 41, as well as in his 'Enumerazione delle Conchiglie mediterranee,' p. 39, and more recently in his 'Nomenclatura di alcune Conchiglie mediterranee,' p. 124.

I have not included in this list the *C. pulchella*, C. B. Adams, from Jamaica, nor the Massachusetts species, viz. *C. Emersonii*, C. B. Ad., *C. terebralis*, C. B. Ad. (which, *teste* Dr. Gwyn Jeffreys, is a *Cerithium*=*C. trilineatum*, Phil., of the Mediterranean), and *C. Whiteavesii*, Verrill (which Dr. Gwyn Jeffreys asserts to be *Cerithium metula*, Lovén, not the Mediterranean species thus called by Delle Chiaje). These lie beyond the limits I have assigned myself; and the same is the case as regards the two species from Wydah in the Bight of Benin (see Proc. Zool. Soc. Lond. 1871, p. 736, pl. lxxv. figs. 21 & 22), regarding which, however, I may say that *C. carinata*, E. A. Sm., is certainly distinct from any North-Atlantic species, and that *C. gemmulifera* has suffered from exfoliation so as to have become unrecognizable.

The species with which I have to deal may be classified thus:—

I. Those with a smooth apex.

1. Apex somewhat stiliform.

(1) *Cerithiopsis tubercularis*, Mont.

(2) *C. Jeffreysi*, Wats.

2. Apex not stiliform.

(3) *C. costulata*, Möller.

II. Those in which the longitudinal ribbing of the apex is notable.

1. Apex somewhat stiliform.
   (4) *C. Barleei*, Jeffr.
   (5) *C. fayalensis*, Wats.
2. Apex not stiliform.
   (6) *C. tiara*, Wats.

III. Those in which the spiral threads of the apex are notable.
   (7) *C. Clarkii*, Forb. & Hanley.

IV. Those in which the apex has ribs and one or more spirals.
   (8) *C. diadema*, Wats.
   (9) *C. atalaya*, Wats.

V. Those in which the apex is fretted or reticulated.
   (10) *C. Metaxæ*, Chiaje.

(1) C. TUBERCULARIS, *Mont. Test. Brit.* p. 270 (Murex).

Has a small elongated apex, which is in form slightly conical, but more nearly cylindrical, consisting of four small, perfectly smooth, convex whorls parted by a horizontal slightly impressed suture; the tip is rounded and immersed. On the base of the shell is a circumbasal thread separated from the tubercled threads on the side of the body-whorl by a deep narrow furrow; another thread encircles the base of the pillar; between these threads is a broadish shallow basal furrow; on the pillar near its foot and behind the lip-edge is more or less of a twisted swelling (the scar of the old canal) simulating a thread.

Hab. Great Britain to Madeira and the Mediterranean.

(2) C. JEFFREYSI, *Wats.* (=C. pulchella, *Jeffr. Ann. & Mag. Nat. Hist.* 3rd ser. vol. ii. p. 129, pl. v. fig. 8, but name preoccupied by C. B. Adams).

Is in general form of straighter outline than *C. tubercularis*, Mont.; the individual whorls are more convex; the longitudinal ribs and the spiral threads are finer, and the tubercles at their intersections smaller, with much larger open square interstices; the embryonic apex, which is also perfectly smooth, is a little smaller and narrower, in particular the third and fourth whorls are narrower and less tumid, and the suture is more oblique. On the subconical and not depressed base there is only one feebly tubercled thread, and it is circumbasal; within it are radiating lines; a scar of the old canal encircles the pillar a little above its foot; the pillar is rather long and narrow.

Hab. Plymouth, Guernsey, Cornwall, in England; Antrim in Ireland; Villafranca (*Jeffreys*), Sicily, Naples, in the Mediterranean. Fossil in the Tertiaries of Calabria (*Monterosato*).

(3) C. COSTULATA, *Möller, Kröyer's Tidsskrift*, vol. iv. p. 83, 1842 (Turritella).

This species is broad, stumpy, and little like a *Cerithiopsis*: the whorls are convex, the suture impressed; the longitudinal ribs are strong, the spiral threads feeble and few; the flatly conical base is levelled up so as to hide both ribs and threads, but is scored by faint convex lines; the edge of this raised flat forms a strong circumbasal thread; round the base of the pillar twists an almost obselete thread, the scar of the old canal. The apex is cylindrical, and consists of three convex short broadish nearly equal whorls, of which the first two are doubtfully fretted with very faint microscopic spiral scratches, and the third has besides about twenty-five very fine, barely convex, unequally parted riblets: the extreme tip is subtumid, but not prominent.

Hab. Greenland (*Mörch*), in 1622 fathoms (*Wallich*), to Fundy Bay (*Verrill*); Iceland (*Torrell*); Norway, from the North Cape in 80 to 300 fathoms (*Sars*), to S. Sweden and Shetland, 84–86 fathoms (*Jeffreys*). Fossil in the Post-tertiaries of Scotland and Sweden.

(4) C. BARLEEI, *Jeffr. Brit. Conchol.* iv. p. 268.

Is broad and conical, with a large but rather shallow suture; the ribs and spiral threads are nearly equal, and their intersections are not very strongly tubercled. The apex, though it has about half a whorl more, is very like that of *C. fayalensis*, having the extreme tip smooth, and the succeeding whorls longitudinally ribbed; but in *C. Barleei* these riblets, of which there are about thirty on each whorl, are very fine, like hairs, and their interstices are microscopically fretted with very faint spiral scratches. The first regular whorl has three spiral threads which cross longitudinal ribs very like themselves. In *C. fayalensis* the apex is slightly shorter than in *C. Barleei*, the longitudinal riblets are stronger, less superficial, fewer (about twenty to a whorl), and though oblique they are less so than in *C. Barleei*. The first $1\frac{1}{2}$ regular whorls have only two spiral threads crossing longitudinal riblets which are stronger than in *C. Barleei*. The suture throughout is less strong and open.

On the base of *C. Barleei*, considerably within the edge, there is a flat, rather weak, untubercled or obsoletely tubercled spiral thread, within which the subconical radiatingly striated base is not depressed; a very feeble scar of the old canal encompasses the base of the pillar. In *C. fayalensis* the circumbasal thread is stronger and more nearly tubercled; and the base within this thread is slightly depressed; the scar of the old canal is scarcely traceable.

(5) C. FAYALENSIS, *Wats.* (= C. corona, *Wats. MS.*, see Monterosato, Journ. de Conch. 1875, p. 41, No. 94), *Journal Linnean Society, Zool.* vol. xv. p. 125.

Has an elongately conical apex of four rather short convex whorls, of which the extreme tip is rounded and smooth, and the other three are scored with distinct curved longitudinal ribs. The base, which is a little impressed and strongly radiatingly striate, has a single strong circumbasal thread which is fretted, but hardly tubercled.

Hab. Madeira, 0–50 fathoms (*Watson*); Fayal, Azores, 450 to 500 fathoms ('*Challenger*' *Expedition*, St. 75); coast of Portugal and Spain down to a depth of 220 fathoms at St. 13 ('*Porcupine*' *Expedition*).

(6) C. TIARA, *Watson.* (See Monterosato, Journ. de Conch. 1874, p. 274, No. 168.)

Has a blunt apex consisting of three whorls, of which the rounded tip is smooth and prominent; the two following whorls are strongly longitudinally ribbed; they are all convex, and are parted by a deep suture. The base of the shell is square, and has two small circumbasal threads, both lying well within the periphery; they are parted by a very fine furrow; the outer one is feebly tubercled; the depressed basal flat between the inner one and the pillar is minutely but sharply radiatingly striated.

Hab. Madeira, 0–50 fms. (*Watson*), and Palermo, Sicily (*Monterosato*).

(7) C. CLARKII, *Forb. & Hanl. Brit. Moll.* vol. iii. p. 368, pl. ciii. fig. 6.

Has an embryonic apex of $2\frac{1}{4}$ whorls, which are dull and roughish. The tip is brown, mamillary, and large. The next whorl is rather larger than that which follows, and is bicarinated by two remote strongish threads which gradually approximate. There are only two tubercled spiral threads on the regular

whorls; and these threads form a more prominent feature than the longitudinal riblets; their intersections are marked by square flat-topped largish tubercles. The upper thread becomes broader down the spire, and splits into two approximate tubercled threads; so that on the last whorl there are three rows of tubercles. The lowest thread has a strong furrow below it within the contraction of the base; below this furrow is a large tubercled thread (which does not appear in the figure) occupying nearly the entire base; crowded in on the foot of the pillar is a small thread, darker than the rest. The twisted pillar is very short and stumpy (very much more so than the figure represents), and the canal lies quite in behind it. The whole shell is of a rich glossy dark-chestnut colour. The suture is deeper and less broad than in the figure.

Hab. The Mediterranean. One rubbed specimen was found by Mr. Clark at Exmouth: it had probably been imported.

I owe a sight of the Mediterranean specimen of this species to the kindness of the Marquis of Monterosato, to whose promised monograph I must refer for a figure of this form. The figure in the 'British Mollusca' leaves very much to be desired; it wants the apex, it presents a quite fictitious mouth and pillar, and fails to catch the general sculpture and the ornamentation of the base.

(8) C. DIADEMA, *Wats.* (See Monterosato, Journ. de Conch. 1874, p. 273, No. 167.)

Has a long, narrow, cylindrical, barely conical apex of four whorls, of which the tip is blunt, rounded, and finely spiralled; and is followed by three feebly convex whorls parted by a very slightly impressed suture: these whorls are on the upper part very finely scored with longitudinal riblets, and near the bottom are keeled by a sharp angularly projecting spiral thread. On the base of the shell there are two circumbasal spiral threads, the outer of which lies close to the lowest of the lateral spirals, and is feebly tubercled; the inner spiral is rather prominent, lies well within the base, and is separated from the outer by a broadish but rather shallow furrow; within it lies the flat, barely depressed centre of the base encircling the pillar.

Hab. Madeira, 0 to 50 fathoms (*Watson*); Palermo, Sicily, 54 fathoms (*Monterosato*). The 'Porcupine' got it in 1870 at Benzert Road in 40 to 65 fathoms; at Rasel Amoush, 45 fathoms; and on the Adventure Bank in 92 fathoms, Mediterranean.

(9) C. ATALAYA, *Watson.* (Hebrew עֲתָלְיָה, a Phœnician word for a watch-tower.)

Has a long, narrow, subcylindrical apex of four whorls, which are parted by a broadish, very slightly impressed suture: the tip is blunt, rounded, and smooth (or perhaps, when quite fresh, very faintly fretted); the other three apical whorls are very finely scored longitudinally by slightly fretted riblets which, near the bottom of each whorl, are cut across by two small approximate spiral threads. On the base just within the contraction is a single circumbasal thread, between which and the pillar the base is very slightly and flatly depressed, and is scored across by minute radiating bars.

Hab. Madeira, 0–50 fathoms (*Watson*).

(10) C. METAXÆ, *auctorum* (*Chiaje?* See Monterosato, Nomenclatura, p. 125.)

Has inferiorly convex whorls and an impressed suture. It is excessively long, with very straight profile-lines. The apex consists of four nearly cylindrical and almost equal whorls, of which the first is subtumid, with a slightly immersed tip; it and the following whorl are completely covered with minute microscopic frettings or stipplings which, especially above the suture, are seen to be arranged in spiral lines: the next two whorls are scored with longitudinals, which above at the suture are straight and distinct (though very fine) bars twenty-five to thirty in number, but lower down become wavy and somewhat obsolete. The base a little within the periphery is encircled by a strong untubercled thread: the middle of the flattened base, which is slightly sunken, is scored with very fine hair-like convex lines; round the base of the very short, broadly conical, and small-pointed pillar coils a very obsolete thread, the scar of the old canal.

Hab. From Shetland to the Canaries and the Mediterranean.

In this species it is not difficult to separate two varieties, in one of which the whole surface of the shell is comparatively smooth; in the other it is angular and bristles with points: it is the latter which is the *C. angustissima*, Forbes; the other is *C. rugulosa*, Monterosato. The two forms, however, run into one another; and the very curious microscopic sculpture of the apex is identical in the two. A really remarkable approach to the latter form (*C. rugulosa*) is presented by the *Bittium abruptum*, Watson, from Fayal, Azores (see 'Challenger Prelim. Report,' Linn. Soc. Journ., Zool. vol. xv. p. 119); but the apex is entirely

R.B.Watson. LINN. SOC. JOURN. ZOOL. VOL XIX. Pl. 4.

SPECIES OF CERITHIOPSIS

1. tubercularis. 2. Jeffreysi 3. costulata. 4. Barleei 5. fayalensis. 6. tiara. 8. diadema. 9. atalaya. 10. Metaxæ.
(sp. 7 not figured.)

Berjeau del. Mintern Bros. imp.

diverse, and is constant in its diversity; and there are other differences which, though eluding attention at first, are really very marked.

DESCRIPTION OF PLATE IV.

All the shells are considerably enlarged; the apices of each still more magnified.

Figs. 1, 1 *a.*	*Cerithiopsis*	*tubercularis*, Mont.	
2, 2 *a.*	"	*pulchella*, Jeffr.	
3, 3 *a.*	"	*costulata*, Möller.	
4, 4 *a.*	"	*Barleei*, Jeffr.	
5, 5 *a.*	"	*fayalensis*, Wats., n. sp.	
6, 6 *a.*	"	*tiara*, Wats., n. sp.	
8, 8 *a.*	"	*diadema*, Wats., n. sp.	
9, 9 *a.*	"	*atalaya*, Wats., n. sp.	
10, 10 *a.*	"	*Metaxæ*, Chiaje.	

The above figures correspond with the numbers in the foregoing description, but No. 7, *C. Clarkii*, is not here figured, having already been illustrated in Forbes and Hanley, *l. c.*

On the Anatomy of the Ambulacra of the Recent *Diadematidæ*. By Prof. P. MARTIN DUNCAN, V.P. Linn. Soc., F.R.S., &c.

[Read 5th March, 1885.]

(PLATE V.)

CONTENTS.

I. INTRODUCTION.

In a communication on some hitherto unobserved structures of the Arbaciadæ, which was read before this Society by Mr. Percy Sladen and myself on February 5, 1885, we stated that the classificatory part of our essay would be given subsequently.

At that time we were not aware of the bearing of some of the structures of the test of the Diadematidæ on the general question

of the classification of the group of Echinoidea with triple pairs of pores; but probably the readers of this communication, which relates to the genera *Diadema*, *Echinothrix*, *Centrostephanus*, *Astropyga*, *Micropya*, and *Aspidodiadema*, will consider, with us, that it should appear before the second part of the essay by Mr. Percy Sladen and myself.

II. Genus Diadema, *Gray*. Diadema setosum, *Gray*.

This well-known form usually breaks anywhere than at the sutures which separate the plates of the test. The test is thin, and is well covered with a semi-leathery tissue when dry, and the plates have much connective tissue between them.

Tests were carefully denuded by means of chloride of lime and exposure to the weather, and there was no difficulty in then separating any plates except the triplets of the compound ambulacral plates. Reagents, such as benzole, render the lines of the sutures of those firmly united plates visible.

The Ambulacra.—Taking a tubercle-bearing plate at the ambitus, the triplet of large pores, the large perforate and crenulate tubercle, and a very small, yet perfect, tubercle close to the median suture of the compound plate are readily noticed (Plate V. fig. 3).

The pairs of pores are in slight curves, and their direction is rather oblique. The pairs are distant, their peripodia do not touch, and there are often one or more minute tubercles, or granules, between them.

The pores follow the rule regarding the position of triplets, and the lowest or adoral pair is close to the actinal edge of the compound plate and nearer to the median line of the ambulacrum than the other pairs. The second pair is, as usual, the most external of the three, and the first pair is more internal than the second, and yet not so much so as the third pair.

On examining an ambulacrum from within, it was found that the arrangement of the triplets of the compound plates is not the same as that seen in such Triplechinidæ as *Strongylocentrotus*, for the second plate of every combination is the largest of the three, and indeed it composes much of the compound plate. In the poriferous part of a compound plate, the sutures between the first and second, and between the second and third plates are not horizontal, and as they approach the position of the tubercle they converge slightly, so that the second or middle plate becomes nipped

in there and low. Thence the sutures gradually diverge and reach the median or vertical suture of the compound plate at points very distant one from the other. One suture, that between the first and second plates of the triplet, reaches the inner or median edge of the compound plate, close to and below its abactinal angle (Plate V. figs. 1 and 2). The other suture, or that between the second and third plates, attains the median edge close to and above the actinal angle of the compound plate.

As both of these sutures reach the median line, all the plates of the triplet are primaries, and there is no demi plate.

In consequence of the divergence of the sutures internally to the mamelon of the compound plate, the second, or central plate, is the largest, and carries the greater part of the tubercle; the other two plates are pushed adorally and aborally and have suffered compression from above downwards during growth, and they are low plates, except where they expand in height at the region of the tubercle. (Fig. 3.)

The triple combination therefore consists of a long low primary, of a long and internally expanded and tall middle primary, and of a third plate resembling the first plate, more or less.

In the figure (Plate V. fig. 1), it will be observed that the line of suture between the first and second plates does not pass from the adoral pore of the first pair; this is owing to the growth of the plates in height. The corresponding defect in the instance of the adoral pore of the other pairs is due to the same cause; but originally the lines of suture were, as is usual in all *Echini*, and as is indicated on fig. 2.

Throughout the ambulacra the compound plates present variation in their height and breadth, but the succession of the three primaries of the triplets is always the same. The second plate is never blocked out from the median line by a union of the sutures between the first and the third plates.

Usually the sutures cannot be traced on the outside of the compound plate, and the sides of the tubercles are free from any markings; but the application of benzole will sometimes indicate the lines of junction of the plates, and then the mamelon will be seen to lie between the sutures and to belong to the second plate. (Plate V. fig. 3.)

The distinction between the arrangement of the triplets in *Diadema* and the Arbaciadæ is evident, for the first and third plates of the compound plates of the ambulacra of *Diadema*

never become demi plates, but remain primaries *. The cause of the persistence of the low primaries in *Diadema* relates to the method and the rapidity of the growth of the tubercle-bearing second plate, as well as to the amount of downward pressure developed during the growth of the new plates at the radial end of the ambulacra. The plates are all primaries there. (Plate V. fig. 4, 4 *a*.)

In the communication by Mr. Percy Sladen and myself, already alluded to †, we noticed especially the peculiar growth of some plates not far from the radial plate in *Cœlopleurus Sindensis*, nobis. It was noticed that although, in specimens of that species, the triplets of the tubercle-bearing plates at the ambitus were as is usual in the genus, yet more abactinally, and where the downward growth-pressure was not assisted by the expansive growth of the second or tubercle-bearing plate, the adoral and aboral plates of the triplet were not forced to become demi plates: they still remained as long and low primaries. This state of things is exceptional in the Arbaciadæ, but it is normal in the genus *Diadema*.

III. The Structure of the Edges of the Plates at the Sutures.

The Vertical Sutural Edges between the Ambulacra and the Interradia.—The line of suturing is a series of convex triplet-plate ends received into corresponding concavities in the interradial plates. On the exposed edges of both the ambulacral and interradial plates there is a thin, and rather solid, layer at the inner part of the section, and a corresponding structure at the outer or superficial part; but all the intermediate thickness is occupied by a number of excessively thin, straight or wavy, distinct, and long laminæ. They are separated by similarly shaped spaces, which are rarely crossed by any offshoots of the lamellar structure. The lamellæ conform to the windings of the sutural surfaces, and those of one compound plate, or of an interradial plate, are continuous.

The laminæ are not continued across the sutures, and it is evident that the interspaces were once occupied by connective

* Quite at the peristomial edge a plate may become a demi.

† Journn. Linn. Soc., Zool. vol. xix. p. 36, pl. i. fig. 9. (The figures 6 and 9 have been misplaced on this plate; but although on p. 36 and p. 57 the reference is to fig. 6, the drawing is marked 9.)

tissue. The coarsely laminated condition of the plates is not found far inwards, for they are comparatively solid centrally; but it appears that the primitive state of these, and indeed of all the plates of the test, was finely laminate.

The Sutural Edges between the Compound Plates of the Ambulacra.—No special structure is seen, and the edges of the plates are nearly solid looking, the trace of lamination being absent or very slight. But there is some overlapping of the outer surface of one plate over the corresponding surface of the next, and especially where there is a minute tubercle close to the outer edge of the suture. The base of the tubercle overlaps a planed-off surface belonging to the next plate. Moreover, when there are large granules or small tubercles on the successive plates, there is a corresponding overlap.

The Edges of the Median or Vertical Sutures of the Ambulacra.—The small tubercle at the point of each compound plate at the median line plays an important part in this zigzag of sutures.

As the point of one plate is received into the re-entering angle of the junction of two successive plates, and the small tubercle is on the point, so there is beneath it a deeply cut-away or concave surface which corresponds to a projection on the opposed plate. Over this slight projection is, of course, the overlapping tubercle-base, and usually there is a little bevelling there of the angle of the plates of the opposite zone. The faces of the edges of the median sutures are finely laminated, but not so coarsely as those of the sutures between the ambulacra and the interradia.

The Median Sutures of the Interradia.—These are best examined from within the test. The zigzag, or the median or vertical line of suture of an interradium, is very distinct within the test. But the edges of the plates at the median suture are not in a straight line converging at angles, and they are evidently not united along planes perpendicular to the surface of the test. The zigzag is in slight curves, and the adoral edge of the coronal plates at the median suture is curved adorally, and underlaps (in the proper position of the test) a corresponding depression on the edge of the aboral part of the suture of the actinally placed plate.

This underlap is very decided in some places, and when the plates are separated, the lamellar expansion of the adoral part of the suture becomes conspicuous. This lamella is a prolongation of the inner layer of the test.

The opposed edges of both the adoral and aboral sutures are marked by well-developed, distinct, and more or less numerous,

parallel laminæ, separated by corresponding spaces. The laminæ of one edge fit into the spaces of the other and opposed plate, and there is much uniting connective tissue there, in the living form.

Above the ambitus, where the coronal plates are broad and low, the following points may be observed at the median suture.

On the outside of the test, the aboral sutural line is longer than the adoral. Seen from within the test, the adoral sutural edge presents a convex surface, and the aboral a slight concavity; moreover, the edge of the adoral suture slopes from within outwards, and the aboral face slopes in the opposite direction.

The adoral edge has on it the projecting lamella, which is continuous with the inner layer of the test, and also three distinct parallel laminæ, which are stout, long, and separated by corresponding spaces. Externally to these is the outer lamella of the test.

On the aboral edge there are two parallel laminæ with intervening spaces, and these laminæ are distinct from the thin outer and inner lamellæ of the test.

In some plates the number of laminæ may be great, but the example given is a very common one. Sometimes the edges of the laminæ are crenulate, and the amount of inward and outward slope of the face of the sutures varies.

The nature of the vertical suture changes towards the apex, where the plates are high in comparison with their breadth.

The adoral edge, which is the longest, has the inner lamella projecting as a stout process as thick as the narrow, curved, and sharp aboral edge. But the adoral edge has a decided groove externally to the inward overlapping process. It is into this groove that the aboral process of the actinally placed plate fits.

Hence at the apex the vertical sutures of the interradia are characterized by decided underlap and elongated dove-tailing.

The Transverse Sutures of the Interradial Plates.—As a rule, the plates are obliquely placed, and whether they are so or not, the adoral edges are more or less convex actinally, but the aboral edges are the reverse. Near the peristome the faces of the sutures on the opposed plates are nearly flat, or there may be a very slight projection along the middle of the adoral edge.

The edge looks homogeneous, and it is only near to the lateral sutures of each plate that a fine lamination presents itself, the commencement of the sutural development already noticed.

Every now and then perfectly distinct groups of knobs and

corresponding sockets may be seen near the ambulacral and median ends of the interradial plates. They are especially visible close to the sutures which unite the auricles to the interradia.

The knobs and the sockets are evidently modifications of the parallel lines of laminæ, but although their existence cannot be ignored, it cannot be advanced that they contribute to the strength of the suturing. Finally, it appears that very visible grooving and corresponding ridging of the horizontal edges of the interambulacral plates occurs when the tubercles are rather close to the adoral edge of a plate. The base of the tubercle forms a kind of overlap, and this is very significant when other Diadematidæ are considered.

IV. Genus Echinothrix, *Peters*, *Monatsb. Akad. Berlin*, 1854, p. 101.

The critical description of this genus and its comparison with the other Diadematidæ may be read in the 'Revision of the Echini,' by A. Agassiz, p. 413. Both Peters and A. Agassiz state that the structure of the ambulacra in this genus differs from that seen in the genera *Diadema* and *Astropyga*. The ambulacra differ from those of the last-mentioned genera "in having many vertical rows of very small tubercles." The compound plates are numerous in *Echinothrix*, and the number of the pairs of pores in a given vertical space is greater than in *Diadema*. Consequently there is not the room for large primary and big secondary tubercles in the ambulacra of *Echinothrix* as there is in *Diadema*. The triplets of *Echinothrix* are close, and the vertical dimension of the combined plates is small. External appearances would lead to the belief that the arrangement of the sutures of the ambulacra is like that of such Triplechinidæ as *Strongylocentrotus*, as drawn by Lovén, or that it would resemble the diagram drawn of the sutures of the triplet of *Diadema* by A. Agassiz; but a careful examination shows that the plates are arranged after the type of *Diadema*, as explained in a former page, there being no demi plate in the compound plate,—all the plates, however low they may be, from crowding and growth-pressure, being primaries. (Plate V. fig. 6 and 6*a*.)

The specimen of *Echinothrix Desori*, Agass., which I have used in this research was large and well grown, and I have chosen one of the plates, about the tenth from the peristome, which has only

one tubercle upon it, for study, besides a number of unseparated compound plates from the ambitus to the apex.

The Ambulacral Compound Tubercle-bearing Plate, from the inside of the Test after the application of Benzole.—Each plate is much broader than high, and is composed of three plates, the triplet of pairs of pores being arranged as in *Diadema*. The sutures of the poriferous part of the plates are nearly parallel, but those between the first and second and the second and third plates approach just internally to their adoral pores, but do not unite. Thence the sutures diverge and reach the median line, or the vertical suture of the compound plate close to the actinal and abactinal angle of that part of the plate, respectively. Hence the first and third plates, although primaries, are often low, close to the median line, whilst the second plate is large and high there. The reverse of this is seen internally to the adoral pores of the triple plates, for there the second plate is low and the first and the third are correspondingly high. (Plate V. figs. 6, 6 *a*, and 7.)

It is difficult to trace the line of the sutures on the outside of the test, and over the tubercles; but as the benzole dries, the sutures may be seen crossing over or rather passing along the breadth of the plate, approaching one another on the tubercle, having the mamelon between them, and then one passes towards the abactinal and the other towards the actinal angle of the median suture of the compound plate. (Plate V. fig. 6.)

The regular distribution of the pairs of pores, from close to the apex to near the peristome, is very striking when viewed from within the test. The lines of the pairs are very oblique, and the third pair of pores of the triplets is larger than the others, and the adoral pore of this pair is always very large. It is nearer the median line of the ambulacrum than the other pores. As the series of these third pairs are numerous, the large pores just mentioned form definite lines on either side of the median suture and at some distance from it. (Plate V. fig. 7.)

The plates forming the compound plates close to the radial plate are of course small and low, but they are nearly or quite of equal size. The sutural lines pass directly towards the median line, and without any bending, so that the three plates are almost rectangular in shape and all reach the median line. This is the simplest possible arrangement of triplets in a compound plate. A little way down the ambulacrum, the pressure from the coming in of new primaries at the radial plate and the expansive growth

of the inner part of the compound plate where the tubercle is going to be, determine the diminution in the height of the first and third plates, close to the median line.

The Peristomial Region of the Ambulacra.—The character of the triplets gradually alters from a little distance from the ambitus actinally. At a distance from the peristome corresponding to the sixth interradial plate, the ambulacral compound plates suffer from slight crowding from above downwards, and begin to widen, so that the pairs of pores gradually become more and more distant from the interradial sutures. (Plate V. fig. 8.) Instead of there being three plates to each compound plate at the ambulacro-interradial suture, there are only two, and they belong to the first and second plates of the triplet, for the exclusion of the third plate occurs gradually, its external part becoming smaller and smaller in the few triple combinations which are placed near the peristome.

Taking the three compound plates which are in relation to the fifth interradial plate from the peristome, as our example, it will be noticed that the peripodium of plate 2 of the abactinal compound plate is so closely placed above that of plate 3, that there can hardly be room for the extension of this last to the interradial suture. On cleaning the test within, and applying benzole, the absence of the third plate at the interradial edge is very evident (fig. 8), and it is seen that the compound plate is made up there of plates 1 and 2 only. The edge of the first plate at the ambulacro-interradial suture is not as high as that of the second plate. On carrying the eye along the transverse suture between the compound plate under consideration and that placed adorally, the outer edge of the third plate will be seen as an angular process, which terminates slightly externally to the aboral pore of the third pair.

The first plate of this triplet (Plate V. fig. 8) is bounded abactinally by the transverse suture between it and the plate immediately above, and which is the third plate of the triple combination placed abactinally. The external limit of the plate is a low curved edge at the interradial suture. The actinal boundary is a suture which passes from the adoral part of the curved edge just mentioned, towards the median line of the ambulacrum, adorally to the outer pore of the pair and then into the inner or adoral pore. Thence the suture passes inwards and slightly aborally, to reach the median or vertical suture of the compound

plate, not far from the aboral angle. This direction is that of the suture of all the first plates of the triplets of the test placed at and near the ambitus.

The second plate is higher than the first at the interradial suture, and is much the larger at the median line. Its abactinal limit is the line of suture which separates it from the first plate, and which has just been described. Its adoral limit is a small part of the transverse suture between the compound plate under consideration and that placed actinally. Then a line of suture commences and passes from the transverse suture, aborally and inwards with a low curved path, to reach the inner pore of the plate number two. Thence the direction of the suture is towards the median line, and slightly adorally, so that the vertical suture is attained just aborally to the actinal angle of the compound plate (fig. 8, I. 2).

The third plate is much the smaller of the three: it includes the most inwardly situated pair of pores of the triplet, and it reaches the median line, being placed there adorally to the suture just described; but the plate does not come in contact with the interradial suture. The actinal limit of this little plate is the transverse suture between the two compound plates.

The next compound plate (II.) closely resembles that just described, but it is rather higher at the median line. The arrangement of the sutures of the triplets is identical. The pairs of pores are, however, more remote from the interradial suture than those of the compound plate already described. The obliquity of the pores of the pairs in some instances prevents the satisfactory use of the term adoral to indicate the inner pore of a pair, for these may be placed aborally to the other series.

Compound plate the third (III.) has the details of those already described, but it is rather lower at the median line than the second compound plate. Hence it is high externally, where, however, there are only two plates of the triplet visible. Of these the first is decidedly the smaller. The third plate is small, is well removed from the interradial suture, and it reaches the median line, resembling the third plates of the compound plates already noticed.

Further changes have been produced by pressure and growth in the more actinally placed compound plates which are in relation to the interradial plate situated actinally to the last mentioned.

Still nearer the peristome the compound plates diminish in vertical dimensions, and the pairs of pores become very remote from the interradial suture on account of the presence of the ascending process of the auricule; but although the arrangement of the triplets is a crowded one, the triplets of every compound plate can be distinguished, there being no accessory plates.

The principal alteration in the arrangement of the triplets is not externally, but near the median line. The first plate of the combination (plate IV. of the series) is low, and as it approaches the median line it becomes lower, and finally it does not reach the median line. It is a low demi plate. The second plate comprises the whole, or nearly the whole, of the expansion of the plate at the median line. The third plate is small, and sometimes it may reach the adoral angle of the median suture, but with increasing crowding it is shut off from it as well as from the outer edge of the compound plate. (Fig. 5, a' is the line of the auricule.)

The characteristic arrangement of the triplets in this species, and probably it is generic, is that of small, close, low, and more or less rectangular primaries near the radial plate. More actinally the first and third plates of each triplet become low broad primaries, having their smallest height at the median line.

Then below the ambitus the third plate is crushed out externally at the interradial sutural edge. Still more adorally the first plate becomes lower at both ends, and finally it is excluded at the median line and becomes a demi plate in the ordinary acceptation of the term. In no case is there an arrangement as in *Strongylocentrotus*.

In *Diadema* this crowding out of the third plate does not occur, but close to the peristome the first and the third plates barely reach the median line, and are in one or two places demi plates.

The Median Suture of the Ambulacra.—The line of this zigzag is not composed of straight lines forming a succession of angles at their points of union or contact.

The line of suture is marked by a series of symmetrical curves, and thus where there might have been an angle at the median end of a coronal plate there is a convex process fitting into a corresponding concave line between the two opposed plates. (Pl. V. figs. 7 & 8.)

It is perfectly evident that the junction of the edges of the plates along the median line is not by simple apposition along

a plane perpendicular to the test, but that there is underlap of one series of edges, and overlap of others.

In *Echinothrix calamaris* the same structures occur as in *E. Desori*.

V. Astropyga, *Gray*, 1825.

This genus has species with the ambulacra projecting, and ornamented with large tubercles similar to those of the interradia. The pores are disposed in triple pairs.

The shape of the tubercles is rather like that of those of *Cœlopleurus*, and there is a bare median space near the apex in both genera.

The definition of the genus is given in Dujardin et Hupé, Hist. Nat. des Zooph. Échinodermes, Paris, 1862, p. 506, copied from Desor, Synopsis, p. 83. Each of these authors states that the distinction between *Astropyga* and *Diadema* consists in the former having the pores in triple pairs, whilst the latter has them disposed in simple pairs, but forming arcs and undulating zones around the ambulacral tubercles.

In the 'Revision of the Echini' by A. Agassiz, the genus is considered critically (p. 417). It is noticed that the tubercles of both areas are perforate and crenulate, and that the poriferous zone of the ambulacra is broader than in *Diadema*, and nearly as broad as the median ambulacral space. The pores are arranged in four irregular vertical rows forming steps of pores of three and one pair. In explaining the characters of *Astropyga pulvinata*, A. Agassiz observes that the ambulacra have the vertical rows of primary tubercles distant, frequently only every other plate carrying a primary, the opposite being only a secondary.

Reference is made to the general appearance of the ambulacra of *A. radiata* on page 421 of the 'Revision.'

The genus is very critically considered in the Report on the Echinoidea, 'Challenger' Expedition, p. 72, under the Echinothuridæ, and there are some important illustrations on plate x *a*. figs. 8 & 9.

Although the minute construction of the ambulacra is not considered, there are important observations on the division of the coronal plates above the ambitus, and the lapping of the transverse sutures of the areas. The following statement relates to a part of these researches in the anatomy of the test. "The lapping of the coronal plates in the Echinothuridæ is not so

absolutely a characteristic feature of the family as has been supposed. It exists already well developed in *Astropyga*, but with the important difference that the overlapping of the plates is in the same direction in both areas. The lower edge of the plate passes under the upper edge of the preceding plate" (*l. c.* p. 71). Put in other words, this means that the adoral edge of a coronal plate slopes from the outer surface inwards, in an actinal direction, and that the aboral edge slopes from within outwards in the abactinal direction.

The Ambulacra of Astropyga radiata.—The tubercles are large, perforate and slightly crenulate, and the base of the boss is wide and flattened out. The mamelon is small in relation to the size of the rest of the structure. At the part chosen for illustration (Pl. V. fig. 9), the great tubercle-bearing plate is apparently followed, apically, by a smaller one carrying a small tubercle, which is placed nearer the pores than the large tubercle. Seen from within the test, the position of the large tubercles is shown by a circular depression (fig. 10); and when the clearing agent is applied, it becomes evident that the large tubercle and the small tubercle are not on separate geometrical plates. The large tubercle as well as the smaller are really in relation with one huge compound plate; and the division of this plate into two is arbitrary, for the transverse dividing line between the two plates either abuts against the salient angle of the zigzag in the median line or close to it. Both plates, together with their aggregate of six component plates, are included in one geometrical, compound plate (Pl. V. figs. 9 & 10). It is best for the purpose of description to consider the great plate as composed of two, each one being made up of a triplet of pore-bearing plates. The edge of the poriferous plates at the interradial suture externally is very irregular, and some pores are quite out of the line (Pl. V. fig. 9). The three pairs and the apparently additional fourth are well seen in relation, but the fourth pair of pores is really the lowest of the triplet of the upper part of the combination. Seen from within, the arrangement of the pairs is very easily understood, especially after the study of *Diadema* and *Echinothrix*.

The illustration, Pl. V. fig. 10, is a diagram founded on magnified views of three great and geometrical plates; and is nearly true. It would be quite so were the effects of the bases of the tubercles on the inside of the test shown, but that would complicate the sutural lines.

In the illustration (fig. 10), the first great plate, A, consists of two sets of triplets. It carries a large tubercle, the concavity of which is seen on the plate, from within the test. The pairs of pores are in a group of three as in *Diadema*; the pores of the third plate are larger than those of the others, and the adoral pore is nearer the vertical suture than any of the others. The arrangement and the shape of the sutures between the triplets are on the type of *Diadema* and *Echinothrix*; but there is this difference, that instead of the first and the third plates suffering from the pressure of growth, the second plate is affected, and so much so that the other plates nearly meet at about the concavity for the tubercle, before their sutures diverge to reach the vertical suture. In this instance there is clearly a very narrow space between the adoral suture of the single first plate and the aboral suture of the third plate of the combination. The three plates are therefore primaries, and there is no demi plate in the combination. The adoral pore of plate 3 is on the transverse line of suture between the first and second sets of triplets of the great plate A. This line reaches the vertical suture adorally to the salient angle.

The first plate of the next triplet (2) is large, and it stretches over to the median line, which it reaches by a narrow termination; for the second plate, also a primary, expands there as well as the third plate. The expansion of the third plate, towards the median line, is considerable, and the result is to push the other plates of the triplet abactinally. There is no tubercle on this part of the great plate A, but the sutures which limit the first and second plates of the triplet nearly come in contact at the spot where a tubercle might have been. The suture placed adorally to the third plate limits the great plate A actinally; and its direction, in the main transverse, is slightly abactinally and towards the median line, for the expansion of the base of the tubercle on the next set of triplets pushes the suture upwards and towards the median line.

The great plate B is made up exactly after the plan of plate A, with this exception. The first plate of its second set of triplets (4, 1) does not reach the median line, being crowded out by the increased size of the second and third plates; so that the second plate is a primary much nipped-in at the position of the defective tubercle, and sufficiently expanded at the vertical suture to form the aboral half of the surface there, and also to reach the transverse suture between the two sets of triplets of

the great plate. The third plate of the triplet is large, and intrudes much on the space which is occupied by a second plate in compound plates placed higher up in the test.

The next great plate, C, differs in detail from the others. The first set of triplets (5) is without a tubercle, and the first of the plates is a long and low primary, with the adoral suture almost transversely placed so that a small portion of the median suture is in contact with the plate. The second plate occupies all the rest of the surface of the compound plate towards the median line, for the third plate is a demi plate. The second set of triplets (6) has a tubercle on it, and the direction of the sutures and the shape of the plates are the same as those of the first set of triplets of the great plate A.

On studying the ambulacra from the outside, but little can be learned regarding the shape of the plates of the triplets; but it is evident that the extremely close sutures noticed from within are more separated externally. The great plate C was rendered sufficiently permeable by light to trace the sutural lines, and some interesting points became evident (Pl. V. fig. 9).

Commencing with plate 1 of the aboral triplet, its shape corresponds with that noticed from within; the adoral suture crosses a large secondary and a smaller tubercle to reach the median line. Plate 2 extends beyond plate 3, towards the interradium, and its adoral suture curves at first abactinally, so as to touch the boss of the larger of the secondary tubercles, and then actinally. It then slopes to the aboral edge of the great tubercle of the next set of triplets, conforms to it, and reaches the transverse suture placed between the first and second set of triplets.

The third plate of this first set of triplets does not appear to belong to it, but to make up a plate of the second set. Nevertheless the plate is part of the first set, and the transverse suture of the half great plate limits it adorally. It is a demi plate, for it does not touch the median line.

The structure of the outside of the plate is rendered difficult of comprehension, because the great tubercle on the second set of triplets has grown so as to overlap and cover much of the third plate of the first set.

Plate 1 of the second set of triplets is a long low primary with its adoral suture crossing the aboral shoulder of the ridge at the base of the mamelon, and reaching the median line just adorally to the junction of the upper and lower triplets.

Plate 2 is a primary, comprising the mamelon and much of the base of the boss of the tubercle, and a large part of the surface at the median suture.

The plate 3 is a well developed primary which pushes plate 2 abactinally, and forms a part of the boss of the tubercle and also of a small part of the compound plate near the median line.

Astropyga pulvinata, Agass.—The details of the ambulacra of this species resemble those of *Astropyga radiata*, allowance being made for the difference in the dimensions of the tubercles in the two species.

The lapping of the coronal plates of the interradia is well seen in these forms; and the underlap of the aboral edge of the interradial plates at the vertical suture, by a thin process of the adoral edge of the abactinally placed plate, is distinct.

I have failed to notice the division of the interradial plate above the ambitus, described by A. Agassiz, in both species.

It will have been noticed that whilst the triplets of *Astropyga* are arranged, not after the type of the Triplechinidæ, but after that of *Diadema*, they differ from those of the last-named genus by being here and there made into demi plates, not, however, after the type of *Strongylocentrotus*, but rather after that of *Cœlopleurus*.

The union of the two sets of triplets in one great plate is very remarkable.

VI. Genus Centrostephanus, *Peters*, 1855.

A. Agassiz appears to consider this genus in the light of a subgenus of *Diadema*, for the word *Diadema* is placed in brackets before the generic term in the 'Revision.' Certainly the external resemblances of *Diadema* and the genus are great, and the presence of ten buccal plates with spines and pedicellariæ, the principal peculiarity of *Centrostephanus*, is only subgeneric.

The only specimen that I have seen shows that the ambulacra have the Diadematid character.

VII. Genus Micropyga, *A. Agassiz*, 1879.

Micropyga tuberculata, A. Agassiz, is fully described in the Report on the 'Challenger' Echinoidea, p. 68, pl. vii.

The following are the descriptions given of the ambulacra:—

"In the ambulacral areas the primary tubercles, arranged in only two vertical rows, increase regularly in size towards the ambitus, where they, as well as the interambulacral tubercles, are largest, and while occupying there nearly the whole of the ambulacral plates between the poriferous zones, become reduced on the abactinal surface to small secondary tubercles placed in the centre of the plates, which carry, besides, a few small miliaries or granules, occurring irregularly on the plates."

"The poriferous zone is of nearly uniform width, from the actinal edge to the apical system. There is no tendency to expansion of the poriferous zone at the actinostome." It had been noticed in dealing with the generic details, that "the poriferous zone is narrow, the pores are in pairs arranged in two vertical rows."

After studying the ambulacra of two dry specimens at the British Museum, I am able to add to this description. At the ambitus, the non-crenulate but perforated large tubercles are on alternate plates of the same ambulacral zone, the intermediate plates are smaller and carry from one to three large granules. Towards the apex there is a tubercle on every plate, and one is larger than the other. Near the radial plate the crowding of the ambulacral plates soon begins to be seen; and in the specimens examined there is, on the contrary, a simple single row of pairs of pores close to the peristome. There is no crowding there whatever.

As A. Agassiz has so well shown, the pairs of pores present a remarkable appearance in being placed nearly throughout the zones in two rows—an outer and an inner, and close together. See the drawings on pl. vii. figs. 4 & 5, 'Challenger' Report.

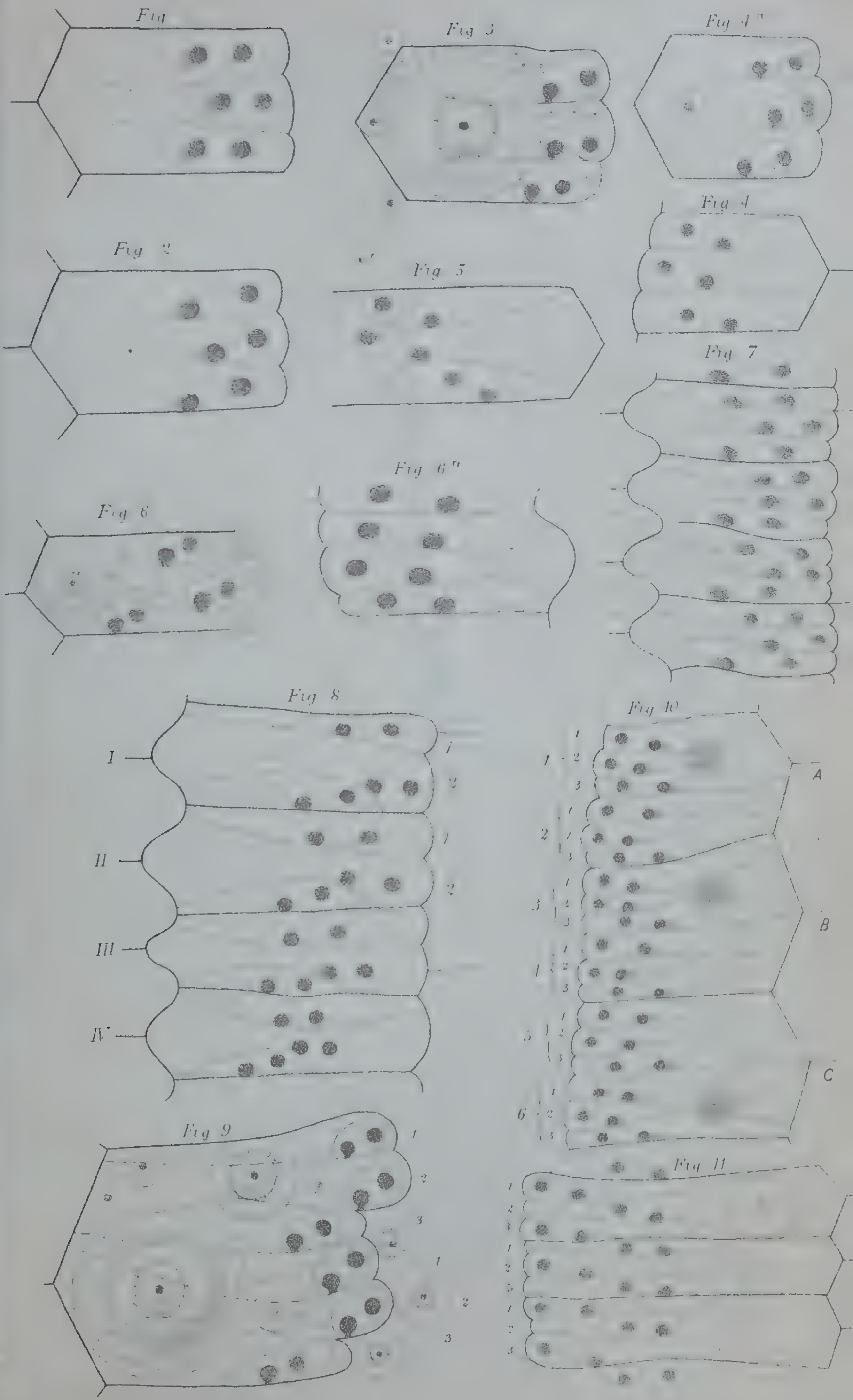
In order to examine the meaning of these two rows, which at first would seem to have no relation to series of triplets, part of ambulacrum II, near the ambitus, but above it, was chosen. It became evident, after the application of benzole, that every compound ambulacral plate is in relation with three of the pairs of pores; and that whilst the tubercle-bearing or larger plate has two pairs of the outer row of pores and one pair of the inner row associated with it, the plate immediately actinally, and which has not a large tubercle, has two pairs of the inner row and one pair of the outer row connected with its component plates. (Pl. V. fig. 11.)

The ambulacral plates are, on the whole, low and broad, and, except close to the apex and peristome, are compound plates, each being made up of three plates, of which the aboral and adoral, or Nos. 1 and 3, are small, low, and demi plates; and the central, or No. 2, is a primary plate expanded towards the median line, supporting the tubercle or the granules, and very low and sometimes almost linear, towards the interradial or poriferous extremity.

The drawing on Plate V. fig. 11, is slightly diagrammatic, and it explains the relative position and the shapes of the triplets of three consecutive compound plates. The upper compound plate has two pairs of the outer row of pores, and they correspond with the plates 1 and 3, which are demi plates, not reaching the median line of the ambulacrum. It has also one pair of the inner row of pores on plate 2, which is almost linear in form externally where it is crowded in between plates 1 and 2, and large towards the vertical suture, which limits it entirely at the median line of the ambulacrum. This plate is then a primary. The plate 1 becomes a demi plate, because the suture at its adoral edge, after passing actinally to the outer pore of the pair, comes in contact with the adoral pore, and then, after a course directly towards the median line, suddenly turns abactinally on the aboral shoulder of the tubercle to reach with a curve the transverse suture of the compound plate next in abactinal succession. The third plate of the triplet is a demi plate because its aboral suture, after passing actinally to the outer pore of the pair belonging to plate 2, touches the adoral pore of that pair, and thence the suture, after a short course towards the median line, turns actinally, with a curve, and reaches the transverse suture, which is placed actinally to this plate 3. The adoral and aboral shoulders of the tubercle on the compound plate are just touched by the curved sutures just mentioned.

This position of the triplet of pairs of pores is quite exceptional in the Diadematidæ.

The arrangement of the pairs and the dimensions of the triplet in the next or actinally situated compound plate are as follows:—The compound plate has no large tubercle, and it is lower than the plate above. It has two pairs of the inner row of pores, connected with its demi plates, and one pair of the outer row in association with the central or second plate, which is a primary.



AMBULACRA OF RECENT DIADEMATIDAE.

Plate 1 is a low demi, of the same shape as the corresponding plate in the compound plate above, but the part of the plate toward the interradium is very low in consequence of the height of plate 2 at that part. Plate 2 is of the same shape as that already mentioned in considering the other compound plate, but the pair of pores is near the interradial edge, and so the plate is not low there. Towards the median line the plate expands, and it forms the whole of the compound plate there. Plate 3 is a demi plate, but the pair of pores is in the normal position, and is nearer the median line than the pair of plate 2.

The alternation of the position of the pairs of the demi plates and of the central primary is unexampled. The relative position of the plates is not that of *Astropyga*, and it has a kind of similitude to that seen in *Cœlopleurus*. Certainly the arrangement is generic and most distinctive.

VIII. Genus Aspidodiadema, *A. Agassiz*, 1879.

Having had the opportunity of examining specimens of *A. microtuberculatum*, A. Agass., at the British Museum, I can testify to the ability and truth of the description given by A. Agassiz of this interesting dweller in the deep ocean (Report on the 'Challenger' Echinoidea, p. 64, pl. viii. figs. 10–16).

One of the specimens is fractured, and I have been able to compare the drawing of A. Agassiz of the outside of the ambulacra with the structure on the inside of the test. There is but little difference, and, as might be expected, the adoral pore of each ambulacral plate is on the transverse suture between two of the plates. The plates are not in triplets, are narrow, and a little broader than high. Each plate is independent of that placed above and below, and in fact the ambulacra resemble those of the Cidaridæ. Of course the simple plates of *Aspidodiadema* are the analogues of the newest or last-formed plates of the Diadematidæ, close to the radial plate, and of those of the Cœlopleuridæ and Temnopleuridæ in similar positions.

DESCRIPTION OF PLATE V.

Fig. 1. *Diadema setosum*, Gray. An ambulacral compound triplet plate, seen from within, after the application of benzole. Magnified.

2. A compound plate between the ambitus and the radial plate, from within. Magnified.

3. An ambulacral compound plate near the ambitus, external view. Magnified. The sutural lines are visible after the application of benzole when the light is cast through the test.

Fig. 4. A compound plate close to the radial plate, from within. Magnified.
a. A similar plate, lower down, seen on the outside. Magnified.

5. *Echinothrix Desori*, Agass., sp. A compound plate, four or five from the peristome; x' is the line of the auricule. Magnified.
6. The tenth compound plate from the peristome. Magnified. *a.* The same, from within.
7. A part of ambulacrum No. 1, seen from within. There are four compound plates and a part of a fifth. Magnified.
8. Some ambulacral plates near the peristome. Magnified.
9. *Astropyga radiata*, Gray. A compound plate (Plate C. of fig. 10) made up of two triplets, after benzole. Magnified.
10. Part of an ambulacrum, plates A, B, C, seen from within, showing the arrangement of the triplets and the circular depressions which correspond with the bases of the tubercles on the outside of the test. Magnified.
11. *Micropyga tuberculata*, Agass. Three compound triplet plates of an ambulacrum above the ambitus. External view. Magnified.

All the figures are slightly diagrammatic.

Description of a new Species of Minyad (*Minyas torpedo*) from North-west Australia. By Professor F. Jeffrey Bell, M.A., Sec. R.M.S. (Communicated by Dr. Günther, F.R.S., F.L.S.)

[Read 16th April, 1885.]

The Trustees of the British Museum have lately acquired, by purchase from Capt. Beckett, who has been sailing among the islands which lie to the north-west of Australia, an interesting example of this rare and little-known group. So little is known

Upper surface of *Minyas torpedo*, n. sp. × 2.

with regard to the Minyadidæ—the 'Challenger' even collecting but few specimens—that a short communication, though based on but a single specimen, may be of interest to the Society.

Description of the Specimen.

External Form.—The body is rounded, flattened above; marked by twenty grooves which extend from near the apex to the edges of the oral disk; they are fainter near the disk than elsewhere in the wall of the body. The integument between each groove is marked by transverse lines, which do not always extend from groove to groove, and so present a gyriform rather than a sulcate appearance. The apex of the air-chamber is exactly at the aboral pole, and though the body-walls are strongly contracted it is quite apparent; the circular sphincter which surrounds it is marked off by a circular groove from the body-wall, and has an extraordinarily close resemblance to the periproct of a regular echinid.

Colour greenish brown.

Measurements.—Diameter 15, height 10, diameter of oral disk 4·2, diameter of orifice of air-chamber 1·5, diameter of circular sphincter 4 millim.

Mouth deeply withdrawn.

Tentacles.—Numerous, short, simple; no perforation to be detected at their tip; apparently dicyclic, but the appearance may be due only to crowding.

Mesenterial Septa twenty; corresponding to the grooves of the wall.

Air-chamber spacious, not communicating with the gastric cavity or its annexes; not hollow, but containing a body of gelatinous appearance in spirit, which is found under the microscope to be formed of fine fibres of connective substance.

Zoological Affinities of the Specimen.

The latest definition of the group to which the specimen belongs is that of Dr. Andres; but as he merely refers to the habit of swimming freely on the surface, we must go back to that of Milne-Edwards and Haime, who group together all such Actinidæ as have the pedal disk purse-shaped under the head of the Minyadinæ; these may have the tentacles smooth or composite, and the former may have the integument verrucose or smooth. It is in the last division that the specimen now under study will have to be placed. The only genus now in the division is that of *Plotactis*, which is thus defined by its authors (Milne-Edwards and Haime):—“ Tentacules simples et allongés; corps

rugueux, mais sans tubercules verruciformes." I see no reason for not placing the new specimen in this genus; but I may suggest that as *Minyas* differs only from *Plotactis* by the presence of verrucæ, it would be better to unite the genera, and to use, of course, the old and well-known term of *Minyas*. The genus *Oceanactis*, instituted by Moseley*, has one row of costal tubercles, and so far would be intermediate between *Minyas* and *Plotactis*; it is distinguished, however, by the connection between the air-chamber and the cœlenteric cavity. *Nautactis* is distinguished by its composite tentacles.

The recognition of the two genera *Minyas* and *Nautactis*, and the grouping under them of most of the species now known, appears to be a wiser plan, and one that is more in accordance with the habit of zoological students than that which has unfortunately been taken by Dr. Andres†, who has instituted four new genera to take the place of those already known. This is not the place, nor is mine the wish, to criticise Dr. Andres's work; but I cannot but express regret at what he has done.

The specimen now under consideration may be called *Minyas torpedo*.

To the morphologist the point of greatest interest with regard to the species is that it makes yet another example of the exceptions to the rule that the Actiniaria in their adult state present a hexamerous arrangement of their parts.

P.S.—Since the above was communicated to the Society, Prof. Stewart has shown me a specimen from New Zealand which he has discovered in the stores of the Museum of the Royal College of Surgeons. It is hardly in a condition for description; but I find in it a confirmation of the view that *Minyas* and *Plotactis* are not to be distinguished generically.

* Trans. Linn. Soc. (2) i. (1877) p. 296.

† Die Actinien. 'Fauna u. Flora des Golfes von Neapel,' ix. pp. 349–355. Dr. Andres has omitted to notice that Mr. Moseley's figure of *Oceanactis rhododactyla* is expressly said to be "twice the natural size," or he would not have said "Dimensioni non date."

On some Colydiidæ obtained by Mr. Lewis in Ceylon. By DAVID SHARP, M.B. (Communicated by GEORGE LEWIS, F.L.S.)

[Read 15th January, 1885.]

(PLATE VI.)

MR. LEWIS, on his return from Japan, spent the winter of 1881–2 in Ceylon, and amassed during his few months' residence there a most interesting collection of Coleoptera, amounting to nearly 1600 species. In this paper I have described the new Colydiidæ met with by him, and in order to make the subject more useful, I have enumerated all the species, purporting to belong to the family, hitherto described from this very interesting island. I have not, however, included in the list *Ditoma rugicollis*, Walk., because it is not really a member of the Colydiidæ. Mr. Lewis, having examined the type in our National Collection, finds it to be a species of *Lyctus*.

Mr. Lewis met altogether with thirty species of the family, and the total number enumerated in this paper is thirty-nine, belonging to twenty-six genera, two or three of which are altogether doubtful. As no thorough exploration has been made of the Coleopterous fauna of Ceylon, we may feel sure that this number is but a small portion of what may be found in the island when it is completely investigated.

NEOTRICHUS SERRATUS, n. sp. (Plate VI. fig. 1.)

Cylindricus, fusco-niger, opacus, setulis sordide albidis erectis parce adspersus; prothorace subquadrato, lateribus fortiter serratis, rude granulato; elytris fortiter seriatim punctatis. Long. 4½ millim.

Antennæ with the penultimate joint very strongly transverse. Thorax quite as long as broad, nearly parallel-sided, the surface densely covered with coarse granules, those at the sides projecting as small tubercles, giving a serrate appearance, each of the lateral tubercles bearing an outstanding seta; a very indistinct broad depression along the middle in front. Elytra with quite regular series of coarse punctures, and having, in certain positions, an appearance of being finely tuberculate. Under surface quite dull, ventral segments deeply and rather closely punctate; tibiæ conspicuously hispid externally.

This species is readily distinguished from *N. hispidus* by the

more quadrate and less uneven thorax, and the finer sculpture of the elytra; it is also of rather narrower and more cylindric form.

Hadley, Dikoya; twelve examples.

MICROVONUS, nov. gen.

Corpus suboblongum, squamosum; antennæ 10-articulatæ, clava parva, uniarticulata; oculis convexis, squamosis. Prothorax fortiter transversus. Tibiæ lineares, extus squamosæ, tarsi articulis tribus basalibus subæqualibus. Sulci antennarii modice elongati; coxæ anteriores parum distantes; prosterni processus reflexus; coxæ intermediæ et posteriores parum, sed magis quam anteriores, distantes.

This is another of the group of genera having the eyes clothed with a large patch of very coarse scales, and to be placed near *Colobicus*. In appearance it is very similar to *Labromimus*, but is distinguished by the diminished club of the antennæ, this being quite small, longer than broad, and apparently consisting only of one joint, though a close examination shows that there is at the apex of the club evidence of a small terminal joint consolidated with the tenth joint; the other joints of the antennæ bear some scales as they do in *Labromimus*.

MICROVONUS SQUALIDUS, n. sp. (Plate VI. fig. 2.)

Suboblongus, parum convexus, niger, opacus, setulis erectis brevissimis dense adspersus, ante apicem griseo-flammulatus, marginibus setulosis; antennis extrorsum tarsisque rufis. Long. 4–5 millim.

Antennæ short, the first joint concealed, second thick, third about twice as long as broad; club scarcely thicker than the second joint. Head broad, clothed with very short erect scales, those in front pallid. Thorax twice as broad as long, the sides curved, distinctly narrowed behind, the surface only slightly uneven, covered with erect scales like the head; these scales are mostly dark, but there are a few pallid ones across the middle, the sides densely fringed with short scales. Elytra without definite sculpture, likewise covered with short erect scales which are dark in colour, but at the shoulder there is an indistinct mark of pallid scales and a still more obscure one near each side of the scutellum, while at the apex there is a very irregular transverse series of pallid marks forming a flammulate fascia. Under surface opaque, not distinctly punctate, sparingly clothed with fine, grey, setiform scales.

Dikoya; fourteen examples.

Coxelus?

Coxelus? unicolor, *Motsch. Bull. Mosc.* 1863, ii. p. 503.

The description apparently indicates an insect unknown to me. Motschoulsky does not state any reason for doubting that the species belongs to *Coxelus*, but it is highly improbable that it does.

Tarphiosoma.

Tarphiosoma, *Woll. Journ. Ent.* i. April* 1862, p. 373; *Pascoe, Journ. of Ent.* ii. p. 138.

Motschoulsky's genus *Tarphisoma* is not the same as this; but will be found characterized in this paper under the name of *Neoplatus.* Mr. Wollaston's surmise (Trans. Ent. Soc. Lond. 1873, p. 3, note) that the two names applied to the same form proves therefore not to be correct.

Tarphiosoma echinatum.

Tarphiosoma echinatum, *Woll. Trans. Ent. Soc. Lond.* 1873, p. 3.
? Tarphius? pilosus, *Motsch. Bull. Mosc.* 1863, p. 506,

A good series of this species was secured by Mr. Lewis. Although Motschoulsky's description appears to me to characterize the insect subsequently described by Wollaston, I have not at present thought right to adopt his name, the identification not being sufficiently satisfactory.

Dikoya; nineteen specimens.

Tarphiosoma luridum, n. sp.

Sat convexum, nigrum, opacum, hic inde minus conspicue fusco-tomentosum, setulis erectis parce adspersum; prothorace brevi, angulis anterioribus longe productis, acutissimis, lateribus valde curvatis, posterius sat angustatis; antennis pedibusque piceis, tarsis rufis. Long. 4 millim.

This is very closely allied to *T. echinatum*, Woll., but is of darker and more uniform colour, the elytra being not variegate, and destitute of the patches of black squamosity that exist in *T. echinatum*; the after body is less abbreviate, the metasternum a little longer, and the upright setæ are shorter and stouter, not at all acuminate.

Dikoya; nine examples.

Neoplatus.

Tarphisoma, *Motsch. Bull. Mosc.* 1863, i. p. 504; *op. cit.* 1861, i. Tab. ix. f. 32.

As the name *Tarphisoma* is practically the same as *Tarphiosoma*,

* List of Colydiidæ collected in the Indian Islands by Alfred R. Wallace, Esq., and Descriptions of new Species by Francis P. Pascoe, F.L.S., &c. (Nov. 1863).

it becomes necessary to substitute another for it, Wollaston's *Tarphiosoma*, published in 1862, having a slight priority. It is true that Motschoulsky's figure of *T. fasciata* appeared in the Moscow Bulletin for the year 1861; but this cannot be considered sufficient to validate his generic name, though as it is sufficient for the recognition of the species the publication of the species may be considered to date from that of the figure. *Neoplatus* agrees with *Tarphiosoma* in having the eyes protected by the front angles of the thorax and quite destitute of scales, and in the comparatively wide-separated front coxæ and very broad prosternal process, as well as in many other of its characters. *Neoplatus* is, however, of remarkably broad depressed form, and its antennæ are intermediate in structure between the genera with two and those with three joints in the club; the metasternum and ventral segments are not abbreviated as they are in *Tarphiosoma*, the epipleuræ are remarkably broad and horizontal, and the tibiæ are only very indistinctly obliquely narrowed at the extremity; the upper surface, instead of long setæ, bears a variegate tomentum, among which there are excessively short upright scales, so short, indeed, that they can only be distinguished by careful examination, while the lateral margins are closely fringed with somewhat longer, but still short, thick setæ or scales.

NEOPLATUS FASCIATUS.

Tarphisoma fasciata, *Motsch. Bull. Mosc.* 1861, i. Tab. ix. f. 32; 1863, i. p. 505.

Taken freely at Hadley, Dikoya.

TRACHYPHOLIS ERICHSONI. (Plate VI. fig. 3.)

Trachypholis Erichsoni, *Reitt. Stett. ent. Zeit.* xxxviii. p. 328.

Point de Galle and Dikoya; nine examples.

This species is apparently rather widely distributed. Reitter's examples came from Siam and Malacca, and I possess individuals from the Andaman Islands.

TRACHYPHOLIS FASCICULATA.

Trachypholis fasciculata, *Reitt. Stett. ent. Zeit.* xxxviii. p. 328.

This species I have not seen.

COLOBICUS RUGOSULUS.

Colobicus rugosulus, *Pascoe, Journ. of Ent.* ii. p. 123, note.

Dikoya, Bogawantalawa, and Nuwara Ellia; eleven specimens.

This is very closely allied to the Japanese *C. granulosus*; but the eyes bear only very short setæ in the present species, and the explanate thoracic margin is less developed than it is in *C. granulosus*.

Colobicus indicus.

Colobicus indicus, *Motsch. Bull. Mosc.* 1853, ii. p. 503.

Unknown to me.

Cicones minimus.

Cicones minimus, *Sharp, Japanese Colydiidæ*, antè, p. 69.

Kitulgalle; one example.

Cicones coloratus.

Cicones coloratus, *Motsch. Bull. Mosc.* 1863, ii. p. 502.

Unknown to me.

Cicones minutus, n. sp.

Niger, antennis in medio, pedibus elytrisque testaceis, his nigro-variegatis; parce griseo-setosus, in elytris seriebus setarum erectarum. Long. 2 millim.

Antennæ small, the base and apex dark, the very minute intermediate joints pallid. Thorax transverse, rather narrower than the elytra, very slightly curved at the sides, the lateral margin studded with extremely short white scales; the surface a little uneven, nearly black, but bearing depressed pallid scale-like hairs; sculpture quite obsolete. Elytra brownish yellow, with numerous black marks, sparingly clothed with depressed pallid setæ, and in addition with regular series of short, erect, distant white scales; sculpture indistinct, consisting of series of closely placed, rather fine, punctures.

Although extremely close to the Japanese *C. niveus*, I think this is distinct, the antennæ being of different colour, with smaller club, and the thorax less transverse.

Lynford, Bogawantalawa, 2nd March, 1882; a single example.

Cicones bitomoides.

Cicones bitomoides, *Sharp, Japanese Colydiidæ*, antè, p. 69.

Lynford, Bogawantalawa; a single example. This individual is in rather a dirty state, and the elytra have apparently only a single indefinite dark mark.

Trionus opacus. (Plate VI. fig. 4.)

Trionus opacus, *Sharp, Japanese Colydiidæ,* antè, p. 70.

Dikoya; ten specimens.

The individuals are larger in Ceylon than those found in Japan; but I can find no good evidence of any specific distinction.

Xuthia parallela. (Plate VI. fig. 5.)

Xuthia parallela, *Sharp, Japanese Colydiidæ,* antè, p. 70.

Point de Galle and Dikoya; four examples.

Ditoma angustula.

Ditoma angustula, *Motsch. Bull. Mosc.* ii. p. 501.

Although this may possibly be a species of *Xuthia*, the description does not agree with *X. parallela*, and the insect is probably unknown to me.

Aulonosoma tenebrioides.

Aulonosoma tenebrioides, *Motsch. Étud. Ent.* 1858, p. 44.

Unknown to me; although the author states that it belongs to the "Colydiens," I expect it will not prove to be really a member of the Colydiidæ.

Ithris oculata, n. sp.

Rufo-ferruginea, angusta, parallela, parum convexa, opaca, prothorace elytrisque costatis. Long. $2\frac{1}{4}$ millim.

Antennæ short, with broad three-jointed club. Head with large and prominent eyes, and with a carina on the inner side of each eye. Thorax a little narrower than the elytra, longer than broad, very slightly narrowed behind, and very slightly curved at the sides, indeed almost straight, except that the front angles are rounded and depressed; the surface quite dull and rough, but not distinctly sculptured, with two longitudinal elevations along the middle; these are rather widely separated, and the interval between them is somewhat depressed; they do not extend quite to the base, but just inside each, and so close as to appear a prolongation, is a short elevation reaching to the base; midway between the lateral margin and the costa described there is another costa extending the whole length of the thorax. Elytra with the alternate interstices raised so as to form on each four fine costæ in addition to the raised suture; this latter becomes bifid in front near the scutellum; the intervals are entirely occupied by very densely placed coarse punctures.

Under surface dull, not distinctly punctured. Tibiæ slender, almost linear, with minute acute apical outer angle.

Dikoya; two examples.

This little insect much resembles *Xuthia niponica*, Lewis; but the three-jointed club of the antennæ requires that it should be placed in *Ithris*; indeed, in many respects it agrees closely with Mr. Pascoe's description of *I. decisa*, though differing in several other particulars.

METOPIESTES TUBULUS, n. sp. (Plate VI. fig. 6.)

Subcylindricus, nigricans, haud nitidus; antennis, tibiis tarsisque rufescentibus; fronte plana, anterius pubescente; prothorace crebre fortiter punctato; elytris costatis. Long. 4 millim.

Head flattened in front, the anterior part occupied by a patch of flavescent, erect, fine hair. Thorax very convex transversely, just perceptibly narrowed behind, slightly longer than broad, the front angles rounded, not at all prominent; the surface very dull, but with a silky appearance, and covered with moderately coarse and close punctures. Elytra each with five conspicuous ribs, one of which is at the suture, and this, by prolongation outwards at the extremity, connects with the outer rib, thus forming an apical margin; the interstices bear on the middle a rather close irregular punctuation, which does not extend to the base, apex, or outside; the base of the elytra is lobed on each side near the scutellum. Under surface but little punctate. Metasternum very elongate.

Bogawantalawa, 8th March, 1882.

This species is, I have little doubt, allied to *M. erosus* from Batchian. The pubescent front exists on each of the two examples found; but may be a sexual character. The genus is somewhat difficult to locate, and would perhaps best go into Horn's group Deretaphrini; though the front coxæ appear to be contiguous, they are, in fact, separated by a very narrow process, and the hind coxæ are not very widely distant.

MECEDANOPS ORNAMENTALIS.

Mecedanops ornamentalis, *Reitter, Deutsch. ent. Zeit.* 1878, p. 120.

Ceylon, *Reitter*. This is unknown to me; Mr. Lewis met with a specimen which, from his account of it, might probably be this insect, but, unfortunately, lost it by an accident in mounting.

Teredolæmus similis, n. sp.

Cylindricus, parum elongatus, nitidus, niger, antennis pedibusque rufis; subtiliter punctatus. Long. 3 millim.

Antennæ with the middle joints very slender, the basal portion of the club marked off from the pubescent portion beyond it by a very abrupt, almost angular curve. Thorax rather longer than broad, not curved at the side, and just perceptibly narrowed in front, moderately finely and not closely punctate. Elytra with regular series of closely placed fine punctures, and also with a few fine punctures on the interstices.

Although extremely similar to *T. politus*, this species is distinguished by the strongly arcuate line of division between the two portions of the club of the antenna, the basal portion being in addition much smaller than it is in *T. politus*; besides this important character, *T. similis* is smaller, has the thorax straight at the sides, and the punctuation of the wing-cases slightly finer.

On the "Duke's Nose," Dikoya, 22nd December, 1881; two examples.

Teredolæmus? biplagiatus.

Teredus? biplagiatus, *Motsch. Bull. Mosc.* 1863, ii. p. 508.

Unknown to me. We may take it for certain that it is not a *Teredus*, though Motschoulsky gives no reason for the query he has attached to the generic name.

Antibothrus, nov. gen.

Antennæ 11-articulatæ, base haud occulta, clava laxe biarticulata; coxæ anteriores parum, intermediæ magis, posteriores fere late, distantes. Metasternum elongatum; segmenta ventralia marginibus posterioribus incrassatis et oblique truncatis, segmento basali sat elongato, sequentibus duobus simul sumtis vix æquali; tibiæ omnes extus ad apicem acute spinosæ; tarsi graciles, sat elongati, articulo basali sequentibus duobus æquali.

This is another genus near *Bothrideres*, but distinguished by the less distance between the front coxæ, the acute spinose prolongations of the tibiæ, and the slender tarsi with elongate basal joint. The hind margins of the ventral segments are peculiar, being as it were much thickened and elevated, but with the greater portion of the thickening behind shaved off.

Antibothrus carinatus, n. sp.

Rufus, angustulus, parum elongatus, opacus, thorace punctis perparum

profundis, magnis, valde approximatis, interstitiis angustissimis; elytris argute costatis. Long. 3 millim.

Antennæ with the tenth joint much larger than the terminal joint. Head small, closely strigose-punctate. Thorax about as long as broad, truncate in front, the sides finely margined, obtusely angulate in front of the middle; the surface dull, scarcely uneven; the sculpture consisting of large punctures so closely placed that the interstices are merely very fine reticulations. Elytra rather hollowed near the apex at the suture, with the suture a little raised, and each with three strongly elevated fine costæ; the first, or inner costa, extends to the apex, and the second nearly does so, while the outer is strongly elevated behind, and curved round so as to form an acutely raised apical margin.

Dikoya, 30th January, 1882; a single mutilated example.

LEPTOGLYPHUS CRISTATUS, n. sp.

Piceus; antennis, pedibus elytrisque testaceis, his sutura margineque externo fuscescentibus; capite rufo, utrinque cristato; prothorace inæquali, lateribus in medio angulatis; elytris argute costatis. Long. $2\frac{1}{2}$ millim.

Antennæ with large round club, consisting of two joints consolidated, but with the suture separating them still distinct. Head small, but with large convex eyes which are finely faceted, and having on the inner side of each eye a thick, short, strongly elevated crest, giving the space between them the appearance of being hollowed. Thorax hexagonal, a little broader than long, truncate in front, the sides angulate in the middle—hence the hexagonal appearance; the surface rather uneven owing to a broad indefinite impression along the middle, and a shorter one in front of the base on each side; closely and rather coarsely punctured, quite dull. Elytra with the suture slightly elevated, and, besides, each with three fine but strongly elevated costæ; the first and second do not reach quite to the apex, and the first is very greatly elevated behind, while the outer one is continued along the apex to the suture; there is no striation or distinct punctuation. Under surface dull, only very indistinctly punctate, the hind margins of the ventral segments obliquely shaved off.

Hadley, Dikoya, 10th January, 1882; a single example.

Although this little insect differs from its Japanese representative in the structure of the club of the antennæ, I think it would not be right to separate it generically at present.

ANTRODERUS, nov. gen.

Corpus angustum, gracile; caput exsertum; antennæ 11-articulatæ, clava parum abrupta, laxe biarticulata. Coxæ anteriores angustissimæ distantes, intermediæ magis, posteriores maxime, distantes. Metasternum abdominisque segmentum basale elongata. Tibiæ subgraciles, anteriores minute calcaratæ, extus ad apicem haud angustatæ.

This is a peculiar genus, which, notwithstanding its contiguous anterior coxæ, should no doubt be placed in the Bothriderini; the coxæ, indeed, are not absolutely contiguous, being separated by an extremely slender process; the surface of the prosternum is uneven, possessing a very large depression, and a large irregular oblique impression or groove on each side. The basal joint of the antennæ is quite exposed, and is thick, the second being similar to those following it; the club is of the *Penthelispa*-type, consisting of a large tenth joint, with which the smaller terminal joint is but loosely connected. The three basal joints of the tarsi are subequal in length. The basal ventral segment is as long as the two or three following together.

Although the general form and the structure of the legs and antennæ suggest a relationship with *Pycnomerus*, the present genus is widely separated therefrom by the elongate first ventral segment and the costate upper surface.

ANTRODERUS COSTATUS, n. sp. (Plate VI. fig. 10.)

Angustulus, haud depressus, rufus, prothorace elytrisque argute costatis. Long. $2\frac{1}{2}$–3 millim.

Antennæ thick. Head with prominent eyes, the vertex rather obscurely quadricostate. Thorax elongate and narrow, narrower than the elytra, much longer than broad, a little narrowed behind, the lateral margin somewhat prominent just in front of the middle; on the middle in front with a short costiform elevation, which, before it has extended half the length, ceases, to give place to two costæ that extend to the base; and between the middle and the side with an elongate costa extending from the front nearly to the base. Elytra elongate and slender, curved at the sides, each with three slender, acutely elevated costæ, and the suture also costate; the inner rib extends nearly, but not quite, to the extremity, while the second curves round at the extremity, joining the suture, and before the extremity is joined by the raised lateral margin; the outer rib joins the elongate second rib a little distance before the apex; except these ribs there is no other

sculpture. Metasternum with two fine, elongate, raised lines extending backwards from the middle coxæ; first ventral segment with two similar lines extending back from the posterior coxæ; the following ventral plates transversely crenate.

Hadley, Dikoya, 3rd January, 1882; four examples.

EROTYLATHRIS.

Erotylathris, *Motsch. Bull. Mosc.* 1861, p. 130, pl. ix. f. 12; *Reitter, Verh. k.-k. zool.-bot. Ges. Wien*, 1879, p. 508; *Munich Cat. Col.* iii. p. 892.

Machlotes, *Pascoe, Journ. of Ent.* ii. p. 36 (1863).

The above synonymy is given on the authority of Mr. Reitter (*l. c.*); it stands, however, in need of confirmation, for Motschoulsky's figure and description, both of them bad, indicate an insect of more slender form, with thinner and longer antennæ than the species of *Machlotes* known to me possess. Mr. Reitter does not state on what evidence he bases the identification, which is given without any doubt on his part. Although Motschoulsky placed his genus in the Lathridiidæ—where also it is located in the Munich Catalogue—it should, from the evidence he himself supplies, have been placed in the Colydiidæ near *Bothrideres*. The Motschulskyian genus was based on an insect from the mountain Nuwara Ellia in Ceylon, but the species appears unknown to me: at least I find it impossible to believe that his figure and description were taken from the species found by Mr. Lewis in Ceylon, which I therefore describe as new.

EROTYLATHRIS COGNATUS, n. sp.

Piceus, opacus; prothorace quadricostato, costis posterius a fissura transversa profunde divisis; elytris sulcatis, interstitiis argute elevatis, et subtilissime crenatis. Long. 3–4 millim.

This species is extremely closely allied to the Japanese *E. costatus*, so that when the upper side only is examined, the two appear to be conspecific, but beneath there are some important differences between the two. In *E. costatus* there proceeds from the intermediate coxal cavity a very short raised line extending backwards on the metasternum; while in *E. cognatus* this line extends all the length of the metasternum (being, however, obsolete in the middle), and reaches the hind coxa. In *E. costatus* the whole length of the metasternum is covered with a dense, very coarse punctuation; but in *E. cognatus* this sculpture is

finer and more distant. The individuals of both species vary much in size, and the Ceylonese are usually much smaller than the Japanese; the largest of the former, however, attains the size of the smallest of the latter.

Balangoda, 15th March, 1882; three examples.

Prolyctus.

Prolyctus, *Zimm. Trans. Am. Ent. Soc.* 1869, p. 274.
Machlotes, *Horn (nec Pascoe), Proc. Am. Phil. Soc.* xvii. p. 585.

I do not think *Prolyctus* and *Machlotes* (the latter = *Erotylathris, teste* Reitter) should be looked on as one genus, for though the two are allied the differences are too numerous to justify their union. *Machlotes* has the front tibiæ merely angulose at the apex, not strongly spinose; the tarsi much shorter than in *Prolyctus*, the basal joint being, in fact, not longer than the following; the front coxæ comparatively but little separated, the first ventral segment much less elongate, and the thoracic sculpture very extremely developed.

I have some doubt whether I am following a correct course in associating, as I have done, the *Bothrideres bituberculatus*, Reitter, with the North-American insect for which the genus *Prolyctus* was founded; for *B. bituberculatus* has the front, and more particularly the middle, coxæ less widely separated: but, looking at the great general resemblance of the two forms, I am not inclined to propose a new generic name for the Singhalese insect at present; and it is clear that it is better placed in *Prolyctus* than in *Bothrideres*, of which the European *B. contractus* is the type.

Prolyctus bituberculatus. (Plate VI. fig. 9.)
Bothrideres bituberculatus, *Reitt. Stett. ent. Zeit.* xxxviii. p. 347.
Dikoya; a series of twelve.

Dastarcus porosus.
Dastarcus porosus, *Walk. Ann. N. H.* 1858, p. 209.
In Dikoya and at Peradeniya; three examples only. This species inhabits also the Andaman Islands.

Pycnomerus alternans. (Plate VI. fig. 7.)
Penthelispa alternans, *Reitter, Stett. ent. Zeit.* xxxviii. p. 349.
Bogawantalawa and Dikoya; six specimens.

Pycnomerus crassicornis.

Penthelispa crassicornis, *Reitter, Stett. ent. Zeit.* xxxviii. p. 349.

Dikoya; a few examples.

Pycnomerus nitidicollis.

Penthelispa nitidicollis, *Reitter, Stett. ent. Zeit.* xxxviii. p. 353.

Dikoya; a few examples.

Pycnomerus distans, n. sp. (Plate VI. fig. 8.)

Minor, subdepressus, rufulus, nitidus; prothorace fortiter punctato, tenuiter marginato; elytris striatis, striis fere simplicibus, interstitiis latis, impunctatis; antennis 10-articulatis. Long. 2-2½ millim.

Antennæ short, rather slender, with a rather slender acuminate club, which has lost all trace of a division into two joints. Eyes but little prominent; head bifoveolate. Thorax longer than broad, coarsely punctate, the interstices broad and shining; it is distinctly narrower than the elytra, scarcely narrowed behind, the front angles are rounded, and the lateral margin fine and inconspicuous; the striæ on the elytra show only faint traces of sculpture, and the interstices are quite impunctate. Metasternum elongate; tarsi short.

This is a very distinct little insect; but I cannot find any character to warrant its separation from *Pycnomerus*.

Dikoya and Bogawantalawa; eight or nine specimens.

Ectomicrus setosus, n. sp.

Oblongus, rufus, setulis erectis tenuibus minus sparsim adspersus; prothorace dense fortiterque punctato; elytris seriatim fortiter punctatis, interstitiis subconvexis. Long. 2¼ millim.

Antennal club large, pubescent except at the base; eyes very convex. Thorax rather broader than long, truncate in front, sides very finely margined, slightly narrowed near the front angles, the surface coarsely and closely punctate. Elytra with regular series of coarse punctures, the interstices convex, impunctate.

This species in form and appearance is not so different from the genus *Cerylon* as the Japanese *E. rugicollis* is; but, on the other hand, the mesosternal cavity for the reception of the prosternal process is more developed than in the other *Ectomicri*, and this separates it completely from *Cerylon*.

Dikoya and Bogawantalawa; a few examples.

Ectomicrus aper, n. sp. (Plate VI. fig. 11.)

Oblongo-ovalis, convexus, piceo-rufus, opacus, setis elongatis, tenuis-

simis parce adspersus; prothorace omnium densissime, fortiter, profundeque punctato, opaco; elytris seriatim profunde, fortiter denseque punctatis, interstitiis angustis, irregularibus. Long. $2\frac{1}{4}$ millim.

A species readily recognizable by the extreme development of the punctuation of the upper surface. The thorax is transversely convex, distinctly, though only slightly, narrowed in front, and is without lateral margin, or, rather, the very fine lateral margin is numerously interrupted by the coarse punctures. On the elytra the coarse punctures are very closely placed, so that the transverse interstices separating them are very fine: both on the elytra and the thorax there are towards the sides a few extremely long and very fine setæ, in addition to the shorter, but still elongate, setæ that are distributed over the surface.

Hadley, Dikoya; six examples.

Cerylon gracilipes, n. sp.

Suboblongum, ferrugineum, nitidum, setulis brevissimis parcissime adspersum, prothorace fortiter punctato, antrorsum angustato; elytris fortiter seriatim punctatis, haud striatis. Long. $2\frac{1}{4}$ millim.

Antennæ rather slender, but with large club; eyes rather large. Thorax not quite so long as broad, distinctly narrowed from the middle towards the front, rather coarsely and moderately closely punctate. Elytra not striate, but with series of rather coarse punctures, becoming quite fine at the extremity, towards the margins with a few short setæ. Legs slender.

Although the hispid surface escapes observation unless a close examination be made, it is sufficient to distinguish this species from all its congeners known to me.

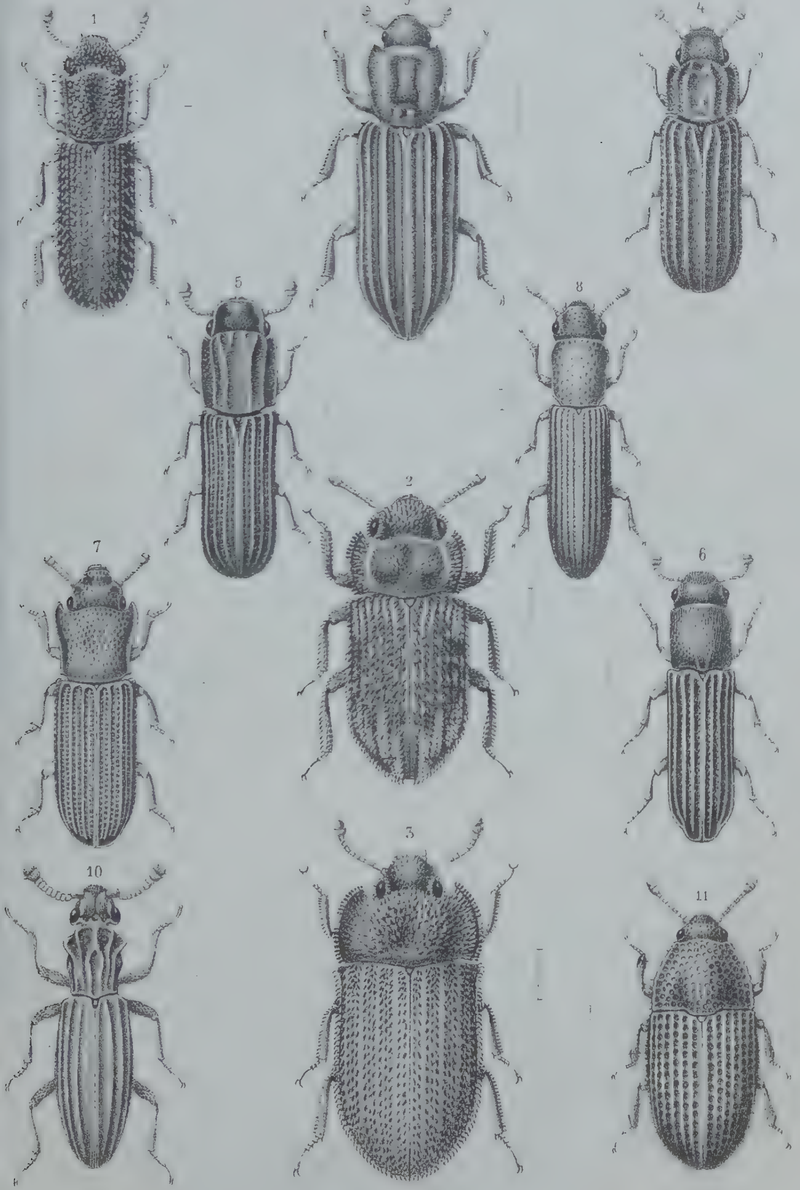
Dikoya; several examples.

Cerylon tibiale, n. sp.

Parvulum, oblongum, angustum, depressum, rufum, nitidum; prothorace tantum subtiliter punctulato; elytris punctato-striatis. Long. $1\frac{3}{4}$ millim.

Mas, tibiis intermediis et posterioribus intus ad apicem incrassato-acuminatis.

Antennæ remarkably slender. Head with the eyes smaller than usual. Thorax quite as long as broad, straight at the sides, the surface unusually finely punctate, a very small basal impression on each side, and an indistinct fovea near each side halfway to the front. Elytra deeply striate, the striæ conspicuously punctate. Under surface but little punctured; metasternum foveolate.



h.v Schereth del. F. Stricker lith. Lith. Anst. v. Th. Bannwarth, Wien

CEYLONESE COLYDIIDAE.

This little insect will be readily distinguished, so far as one sex is concerned, by the unusual development of the middle and hind tibiæ; the species has also the front coxæ more approximate than they are in the normal species of the genus. The middle tibiæ have at the apex an acute mucro internally, while the hind tibiæ have an angular incrassation.

Dikoya and on the Horton plains; six specimens.

CERYLON QUADRICOLLE, n. sp.

Oblongum, depressum, rufo-testaceum, nitidum; prothorace quadrato, crebre sat fortiter punctato; elytris simpliciter striatis, striis ad basin intus curvatis. Long. $1\frac{3}{4}$ millim.

Antennæ short, moderately stout; eyes small. Thorax nearly as long as broad, straight at the sides, emarginate in front so that the anterior angles are prominent, the surface rather coarsely and moderately closely punctate. Elytra deeply striate, but the striæ not punctured, distinctly curved inwards at the base; interstices broad, not punctate. Under surface very little punctate.

This species agrees with *C. tibiale* in the comparative slight separation of the front coxæ; the curved striæ exist also in *C. pusillum*, Pasc., which species, however, has the sides of the thorax rounded.

Point de Galle; two examples.

CERYLON ORIENTALE.

Cerylon orientale, *Motsch. Étud. Ent.* 1858, p. 46.

Unknown to me.

DESCRIPTION OF PLATE VI.

Fig. 1. *Neotrichus serratus*, Sharp.
2. *Microvonus squalidus*, Sharp.
3. *Trachypholis Erichsoni*, Reitter.
4. *Trionus opacus*, Sharp.
5. *Xuthia parallela*, Sharp.
6. *Metopiestes tubulus*, Sharp.

Fig. 7. *Pycnomerus alternans*, Reitter.
8. —— *distans*, Sharp.
9. *Prolyctus bituberculatus*, Reitter.
10. *Antroderus costatus*, Sharp.
11. *Ectomicrus aper*, Sharp.

Description of Australian, Cape, and other Hydroida, mostly new, from the Collection of Miss H. Gatty. By Professor George J. Allman, LL.D., F.R.S., F.L.S.

[Read 19th March, 1885.]

(Plates VII.–XXVI.)

A large collection of Hydroida has been placed in my hands by Miss Gatty for determination and description. It consists mainly of species hitherto undescribed. The specimens have been brought together from various parts of the world; and though they are all dry, they are for the most part well preserved, and the features of most importance in the definition and systematic distribution of the species were generally determined with ease from the chitinous periderm, after this had been subjected to such treatment as would render obvious its essential morphological characters.

No record had been keep as to the depths from which the specimens had been obtained, but it is probable that they are all from the littoral region.

In order to convey an adequate idea of its habit, every species has been figured of the size of life, while such microscopical details as are necessary for a complete diagnosis are in all cases given.*

Campanularia.

Campanularia carduella, n. sp. (Pl. VII. figs. 1, 2.)

Trophosome.—Hydrostyles about $\frac{1}{20}$ of an inch in height, springing at short intervals from a creeping stolon and annulated at the distal end. Hydrothecæ cup-shaped, with tumid base and everted lip.

Gonosome.—Gonangia springing from the creeping stolon, large, oviform, with truncated summit, and with the proximal end continued into a short but well-defined peduncle.

Locality. New Zealand.

This very minute Campanularian is rendered striking by its peculiarly shaped hydrothecæ, whose outline, somewhat resembling that of a thistle-head, has suggested the specific name. While most of the hydrostyles spring directly from the creeping stolon, some may be seen arising from loops formed by short free branches of the stolon curved upon themselves.

The nature of the contents of the gonangia being indeter-

* For the drawings which represent the natural size of the species I am indebted in almost every instance to the accurate and delicate pencil of Miss Hippisley.

minable in the dried specimen, the reference of this remarkable little Campanularian to the genus *Campanularia* is of course only provisional.

The specimen was brought by Dr. Harvey from New Zealand, where it occurred growing over the surface of a seaweed, *Melanthalia abscissa.*

Sertularella.

Sertularella margaritacea, n. sp. (Pl. VII. figs. 3, 4.)

Trophosome.—Stem monosiphonic, much branched. Hydrothecæ distant, adnate by about half their height to the stem, from which they then become strongly divergent, epicauline side ventricose towards the base; orifice with a thickened rim and with a deep sinus at its apocauline side.

Gonosome.—Gonangia springing from the angles of the ramification, ovoid, marked by wide transverse rugæ towards the summit and the base.

Locality. Straits of Magellan. On an air-vesicle of *Macrocystis pyrifera.*

This is a delicate form, attaining a height of about 3 inches, with a very thin pellucid periderm. The gonangium develops an acrocyst, the remains of which are visible in the specimen.

Sertularella capillaris, n. sp. (Pl. VIII. figs. 1–3.)

Trophosome.—Stem monosiphonic, very slender, much branched, branches giving off pinnately disposed alternate ramuli. Hydrothecæ adnate to the internode for about half their height, then becoming free and abruptly divergent; orifice with two very narrow teeth posteriorly and two broader teeth anteriorly.

Gonosome.—Gonangia springing each from a point just below a hydrotheca, pyriform, surrounded throughout their whole length by prominent annular ridges, opening on the summit by a central, scarcely elevated orifice.

Locality. New Zealand.

This species attains a height of about 3 inches, and comes near to the *Sertularella Johnsoni* of Gray, which it closely resembles in habit. It differs from it in the abrupt divergence of the free portion of the hydrothecæ and in the pyriform gonangia.

Sertularella crassipes, n. sp. (Pl. VIII. figs. 4, 5.)

Trophosome.—Main stem strongly fascicled, very thick, sending off a few fascicled branches, from which and from the main stem

are emitted on all sides very numerous monosiphonic twigs which carry the ultimate, pinnately disposed, alternate ramuli, whose internodes are short and thick, separated from one another by oblique joints, and each carrying a single hydrotheca. Hydrothecæ deep, free for about two thirds of their height, and narrowing towards the orifice, which is cut into four rather short and wide teeth.

Gonosome.—Gonangia elongated, oval, springing each from a point near the middle of an internode, narrowing towards the summit, which is occupied by a circular 4-toothed orifice, and gradually tapering below to the point of attachment.

Locality. Cape of Good Hope.

The species is remarkable for its thick polysiphonic stem and short thick internodes. The specimen had a height of about 3 inches, and the stem measured nearly two tenths of an inch in thickness towards its proximal end.

SERTULARELLA CUNEATA, n. sp. (Pl. IX. figs. 1, 2.)

Trophosome.—Main stem fascicled, much branched; branches monosiphonic, pinnate; pinnæ alternate, rather distant. Hydrothecæ closely set, springing singly each from a short, thick, wedge-shaped internode, to which they are adnate for about half their height, much contracted towards the orifice, which is circular and entire.

Gonosome.—Gonangia large, ovoid, much elongated, with shallow transverse corrugations but no true annulation, contracted towards the summit, which opens by a 4-toothed circular orifice.

Locality. Cape of Good Hope.

The short, thick, wedge-shaped internodes, and the long gonangia, which attain the length of about ten internodes of the pinnæ, are striking features in this hydroid. The hydrorhizal end of the specimen had not been preserved. What remained of the colony had a height of about 3 inches.

SERTULARELLA LIMBATA, n. sp. (Pl. IX. figs. 3, 4.)

Trophosome.—Stem springing from a creeping fibre, monosiphonic, simple. Hydrothecæ borne directly by the stem, each springing from a short internode, and all directed towards one side, free for about two thirds of their height, deep, narrowed towards the summit; margin of orifice produced into a broad, thin, membranous rim which is emarginate at the epicauline side.

Gonosome.—Gonangia springing each from a point just below a hydrotheca, nearly globular, with a few shallow transverse

corrugations, opening by a circular orifice, which is surmounted by an acrocyst.

Locality. Cape of Good Hope.

This is a minute but interesting species. It attains a height of about $\frac{1}{4}$ of an inch, and was found creeping over the surface of a seaweed. It is rendered remarkable by the fact that all the hydrothecæ are borne directly by the stem without the intervention of pinnæ. The creeping fibre, however, by which the colony is attached may probably be regarded as a prostrate creeping stem, and then the free portion, which carries the hydrothecæ would represent the pinnæ. The species is further distinguished by the secund disposition of the hydrothecæ, by their membranous rim, and by the nearly globular gonangia with their acrocysts.

Sertularella trimucronata, n. sp. (Pl. X. figs. 1, 2.)

Trophosome.—Stem pinnate, monosiphonic, springing at intervals from a creeping filament; pinnæ alternate. Hydrothecæ borne both by stem and pinnæ, deep, nearly cylindrical; orifice with three strong teeth, two of which are situated anteriorly and one posteriorly; hydrothecæ of pinnæ with their axis all directed towards the same side.

Gonosome.—Gonangium sessile on the side of an internode near the base of the hydrotheca, oviform, marked by shallow annular rugæ, opening on the summit by a narrow, slightly elevated orifice.

Locality. Australia.

This is a very slender and delicate form. It attains a height of about 1 inch; and is characterized by its deep, nearly cylindrical hydrothecæ with tricuspid margin and secund disposition, and by its large, broadly oviform, and narrow-mouthed gonangia.

Sertularella trochocarpa, n. sp. (Pl. X. figs. 3, 4.)

Trophosome.—Main stem monosiphonic, and carrying pinnately disposed ramuli with every internode supporting two alternate hydrothecæ. Hydrothecæ rather wide, adnate for about two thirds of their height to the internode; orifice with two long acute teeth on the apocauline and a single wider tooth on the epicauline side.

Gonosome.—Gonangia springing each from a point just below a hydrotheca, amphora-shaped, surrounded from base to summit with very regular, close-set, annular ridges, and terminating

distally in a funnel-shaped tube which bears the circular even orifice.

Locality. Bass's Straits.

This species attains a height of about 2 inches. The gonangium is a beautiful object, with its strong and regular annular ridges and terminal funnel. Its resemblance to a boy's top has suggested the specific name.

SERTULARELLA DIFFUSA, n. sp. (Pl. XI. figs. 1, 2.)

Trophosome.—Colony much branched; stem monosiphonic, giving off alternate branches which repeat the ramification of the main stem; main stem and branches jointed at distant intervals. Hydrothecæ adnate to internode for about half their height, then strongly divergent and slightly tapering to the orifice, which is bidentate; two pairs of hydrothecæ borne by an internode; widely separated, and with a somewhat secund disposition on the principal branches, more closely set and bilaterally disposed on the ultimate ramuli; main stem destitute of hydrothecæ.

Gonosome not known.

Locality. Rockaway.

The present species attains a height of more than 9 inches. Its habit, with its long flexuous stems and profuse ramification, is strongly suggestive of certain long-stemmed Campanularidans, such as *Obelia longissima* of the European shores. One of its most remarkable characters is found in the presence of more than one pair of hydrothecæ on each internode, a character in which it shows an approximation to *Thuiaria*; while the constancy of the number of hydrothecæ borne on an internode, and their freedom for a great part of their height from coalescence with the internode, offer features more in accordance with the characters of the genus to which it is here referred.

DIPHASIA.

DIPHASIA BIPINNATA, n. sp. (Pl. XII. figs. 1, 2.)

Trophosome.—Stem monosiphonic, pinnate, pinnæ alternate. Hydrothecæ exactly opposite, deep, tubular, adnate to the internode for about two thirds of their height, then abruptly diverging, emarginate at epicauline side of orifice, where they give attachment to a valve-like lid.

Gonosome.—Gonangia (in female) large, springing by a narrow base from a point in the mesial line just below each pair of hydrothecæ, gradually widening upwards and terminating distally

in a marsupial chamber enclosed by four elliptical valve-like segments.

Locality. Cape of Good Hope?

This is a fine species, and attains a height of 3 inches*. The pinnæ towards the distal ends of the stems are generally the longest, and are themselves usually pinnate, thus giving to the hydroid a richness of ramification which is rendered still more striking by the profusion of large, flower-bud-like gonangia which are carried along the front of the pinnæ.

In the young female gonangia before the marsupial chamber is closed in, the orifice of the gonangium may be seen on the summit of a central conical process surrounded by the four young lanceolate marsupial segments.

Synthecium.

Synthecium ramosum, n. sp. (Pl. XII. figs. 3, 4.)

Trophosome.—Colony. Stem monosiphonic, much and irregularly branched, pinnate throughout; pinnæ opposite, equidistant. Hydrothecæ deep, tubular, borne both by stem and pinnæ.

Gonosome.—Gonangia ovate, with the shorter to the longer diameter at about 1 to 1½, strongly annulated, with the annular ridges discontinuous where they meet a zigzag line on opposite side of the gonangium, opening by a short tubular prolongation of the summit.

Locality. Tauranga, New Zealand.

Synthecium ramosum attains a height of 6 inches. It is the second well-determined species of the beautiful genus *Synthecium* †. From *Synthecium elegans* it differs by its greater height and branching habit, and by the more globular form of its gonangia, which in *Synthecium elegans* are considerably more elongated, the transverse diameter being to the longitudinal in that species as about 1 to 2.

* A small specimen has been selected for the figure.

† Heller (Zoophyten und Echinodermen des Adriatischen Meeres, 1868, p. 35, pl. i. figs. 5, 6) describes, under the name of *Dynamena tubulosa*, a hydroid from the Adriatic which can scarcely be regarded otherwise than as a species of *Synthecium*. He, however, represents a gonangium as springing directly from the stem, and though he figures what appear to be the true gonangia in their actual relation to the hydrothecæ, he makes no reference to these in his description, thus omitting the one essential character of the genus. Altogether there is some obscurity in Heller's account, and when he tells us that the species is not rare in the Adriatic, we can scarcely help thinking that there has been some error in the location of his specimen.

These differences, however, obvious as they are, may possibly be only of varietal value, and insufficient to justify a separation of the present form from *Synthecium elegans.*

Sertularia.

Sertularia aperta, n. sp. (Pl. XIII. figs. 1, 2.)

Trophosome.—Stems slender, monosiphonic, much-branched, with the ramification subdichotomous. Hydrothecæ exactly opposite, adnate for about half their height to the internode, and then widely divergent; aperture extending along the whole of the posterior side of the free portion of the hydrothecæ; margin deeply indented at the apocauline side, so as to present here two long sharp teeth.

Gonosome not known.

Locality. Cape of Good Hope.

This is a slender species, the colony attaining a height of about one inch, and with the habit of *Sertularia operculata*, to which it would seem to be nearly allied. It grew upon a seaweed along with *Aglaophenia chalarocarpa*, see p. 150.

Sertularia minima, *D'A. W. Thompson**. (Pl. XIII. figs. 3, 4.)

Trophosome.—Stem simple, monosiphonic, springing at short intervals from a creeping network of tubular fibres, and carrying usually from four to ten rather closely approximate pairs of hydrothecæ, which commence at some distance from the proximal end and are continued to the distal. Hydrothecæ deep, tubular, adnate to the internode for nearly their whole height, and with the apocauline edge of the aperture deeply cleft.

Gonosome.—Gonangium springing from the stem just below the proximal pair of hydrothecæ, large, widely pyriform, destitute of annulation, opening distally by an orifice raised on the summit of a very short wide tube.

Locality. Cape of Good Hope, where it occurs creeping over the surface of a rooted species of *Sargassum*.

This very minute species has been already described by Mr. D'Arcy W. Thompson from the Gulf of St. Vincent, and by Dr. Coughtrey and Mr. Bale from New Zealand and Australia. It attains a height of only one fourth of an inch, and is rendered striking by the large size of its gonangia, which are always borne singly just below the proximal pair of hydrothecæ. The creeping stolon from which the stems arise has the inner layers of its walls

* Ann. & Mag. Nat. Hist. ser. 5, vol. iii. p. 104 (Feb. 1879).

impressed with narrow, closely set, transverse constrictions which project into the cavity of the tube. The gonangia are abundantly developed in the specimen, and, as Miss Gatty has remarked to me, it is deserving of note that the *Sargassum* on which it grows is a rooted species, while on the floating *Sargassum* of the Gulf Stream *Sertulariæ* are rarely if ever found with the gonosome developed—a fact not without significance in connection with the invariable absence of fruit in the floating seaweed, and its presence in the rooted one.

S. minima comes very near to *S. megalocarpa*, from which it is chiefly distinguished by its wider and more extensively adnate hydrothecæ.

Sertularia unilateralis, n. sp. (Pl. XIII. figs. 5–7.)

Trophosome.—Stem monosiphonic, slender, sending off from one side very numerous slender ramuli, which are dichotomously branched. Hydrothecæ nearly cylindrical, divergent, with the epicauline side adnate for about half its height to the internode; apocauline side of orifice deeply emarginate.

Gonosome.—Gonangia borne by the internodes just below the hydrothecæ, in the form of an inverted compressed cone whose axis terminates distally in a tubular orifice, on each side of which the edges of the gonangium are prolonged in the shape of a strong horn-like spine.

Localities. New Zealand and Australia.

S. unilateralis occurs in large close tufts which attain a height of upwards of 6 inches. Each tuft is formed by a multitude of slender filaments carrying closely-set pairs of hydrothecæ along their entire length, and sending off at short intervals equally slender ramuli which are dichotomously branched. These ramuli are entirely confined to one side of the main filament, whose characters they exactly repeat in their slenderness, and in the form and distribution of the hydrothecæ.

The lateral compression of the gonangia causes these to assume a triangular form, the base of the triangle being situated distally, and having its two angles continued into a strong curved horn.

Sertularia crinis, n. sp. (Pl. XIV. figs. 1, 2.)

Trophosome.—Main stem very slender, monosiphonic, sinuous, subdichotomously branched, carrying along its length short alternately disposed ramuli, which soon subdivide into somewhat flabelliform groups of hydrotheca-bearing ramuli. Hydrothecæ deep, adnate to the internode for about two thirds of their epi-

cauline side, and then diverging at an acute angle; orifice very oblique, directed towards the internode, and with its apocauline edge deeply cleft.

Gonosome.—Gonangia springing each by a short peduncle from the side of the internode at a point just below a pair of hydrothecæ, oboviform, with the summit extended into a short wide tube which opens by a circular orifice.

Locality. Tauranga, New Zealand, collected by Dr. Davies.

Sertularia crinis, though attaining a height of upwards of 7 inches, is a very delicate and flexile species. The chitinous periderm is thin and transparent, and the whole colony is destitute of the rigidity so usual among the Sertularian hydroids. It comes very near to *Sertularia bispinosa*, Gray, from which it differs in its more ovate gonangia without angular processes.

SERTULARIA ELONGATA, Lamx. (Pl. XV. figs. 1–6.)

Trophosome.—Stem slender, monosiphonic, sparingly branched, carrying along nearly its entire length alternately disposed closely-set pinnæ. Hydrothecæ subopposite, carried both by the pinnæ and the main stems, tubuliform, adnate to the internode for about half their height, free and divergent for the remainder, with the summit slightly curved towards the internode; orifice with six long-pointed teeth, the two teeth at the epicauline side of the orifice separated by a wide interval; portion of internode between each pair of hydrothecæ much contracted.

Gonosome.—Gonangia springing each almost exclusively from an internode of the main stem, obconical, smooth, opening on the summit by a slightly elevated rather wide orifice, on each side of which the walls of the gonangium are continued into a long strong horn-like spine.

Locality. Tasmania.

Sertularia elongata is a very elegant plume-like species, attaining a height of about 4 inches, and with much of the habit of a Plumularian. Its tubuliform hydrothecæ with their long marginal teeth, and its large horned gonangia afford obvious and striking characters.

A form from West Australia, differing slightly from that here described, is also contained in Miss Gatty's collection. Its gonangia, instead of being almost exclusively confined to the main stem, are all seated on the pinnæ, each pinna carrying usually a single gonangium. The imperfect partition between the cavity of the hydrotheca and that of the internode is here thick and of

deep brown colour, which contrasts with the lighter and more transparent walls of the hypothecæ and internodes, while its free margin is further thickened into a prominent rim, which in optical section has the appearance of a round knob turned forward, or towards the cavity of the hydrotheca. The orifice of the gonangium is encircled by a line of minute punctæ.

Notwithstanding these differences, I do not regard the distinction as sufficiently marked to justify us in viewing the West-Australian form as specifically distinct from the Tasmanian.

The specimen occurs creeping over the stems of a *Caulinia*, thus indicating a shallow-water habitat. Along this zosteraceous plant its elegant plumes extend for several inches.

SERTULARIA CRINOIDEA, n. sp. (Pl. XVI. figs. 1, 2.)

Trophosome.—Stem simple, springing at short intervals from a creeping stolon, to which it is attached by a short spirally corrugated peduncle. Hydrothecæ adnate to the internode by the entire height of their epicauline side, the apocauline margin of the orifice prolonged divergently upwards and deeply emarginate.

Gonosome not known.

Locality. Cape of Good Hope.

Sertularia crinoidea does not exceed $\frac{1}{10}$ of an inch in height. The prolonged and deeply cleft apocauline margin of the orifice confers on the hydrothecæ of this minute *Sertularia* a form which may be compared to that of a mitre. The internodes are short, and the pairs of hydrothecæ closely approximate. The proximal portion of the stem forms a distinct peduncle, which is surrounded by a few spiral corrugations, and the creeping stolon from which this arises has the inner layers of its walls marked by closely-set transverse constrictions, which in optical section are seen projecting into its cavity.

The very short simple stems are closely set on the creeping stolon, and each carries usually five or six pairs of hydrothecæ. Each internode with its pair of hydrothecæ presents a symmetrical and very elegant outline, and when viewed in the plane common to the two hydrothecæ, recalls the form of the flower in certain lilies.

No gonosome was developed on the specimen, which occurred growing over the surface of a seaweed.

SERTULARIA AMPLECTENS, n. sp. (Pl. XVI. figs. 3, 4.)

Trophosome.—Stems slender, monosiphonic, pinnately branched. Hydrothecæ adnate to the internode for somewhat more than

half their height, then diverging at a very wide angle, and terminating in a deeply-cleft orifice; pairs of hydrothecæ distant; hydrothecæ of each pair closely approximate on the pinnæ, more widely separate on the stem.

Gonosome not known.

Locality. Atlantic, attached to floating gulf-weed.

Sertularia amplectens attains a height of about half an inch. It is a very delicate form, rendered remarkable by the close approximation of the hydrothecæ in each pair on the pinnately disposed branches. The stems from which the pinnæ arise also carry hydrothecæ, but these are here subopposite and less closely approximate, while the joints of the stem are few in number and are situated at uncertain intervals.

Viewed laterally, the approximation of the hydrothecæ, back to back, or by their epicauline sides, resembles the characteristic condition of the hydrothecæ in the genus *Desmoscyphus*. In the present species, however, this approximation is the result of the extent to which the internode is embraced by the hydrothecæ, and instead of being, as in *Desmoscyphus*, confined to one side of the internode, it is equally present on both.

No trace of gonangia can be detected, and the frequent absence of gonosome in such Sertularians as are found on floating forms of *Sargassum* and its usual presence in such as inhabit rooted forms, is, as Miss Gatty has remarked to me, a fact worth noting in connection with the absence of a reproductive system in the floating seaweed and its presence in the rooted one.

SERTULARIA MEGALOCARPA, n. sp. (Pl. XVI. figs. 5–7.)

Trophosome.—Stems simple, attaining a height of about $\frac{1}{10}$ of an inch, springing at short intervals by a spirally twisted proximal extremity, which is destitute of hydrothecæ, from a creeping stolon, which is also spirally twisted; internodes separated from one another by a deep constriction. Hydrothecæ exactly opposite, tubular, adnate to the internode for somewhat more than two thirds of their height, and then becoming free and divergent; orifice with its apocauline margin cleft so as to form two acute teeth.

Gonosome.—Gonangia very large, nearly globular, destitute of annulation, springing by a well-defined peduncle from the side of the proximal hydrotheca-bearing internode just below the base of the hydrothecæ, and opening by a terminal orifice, which is supported by a very short cylindrical neck.

Locality. Australia?

The height of the trophosome in the present species does not exceed $\frac{1}{10}$ of an inch. The enormous size of the gonangia as compared with the minuteness of the trophosome constitutes a striking feature in this diminutive *Sertularia*. The height of the gonangium, exclusive of the peduncle, exceeds the combined length of three internodes of the stem, which here resembles a mere appendage to the gonangium, instead of being, as is usually the case, the most voluminous portion of the colony. Only one gonangium is borne by each stem, and this always springs from the proximal hydrotheca-bearing internode just above the peduncle by which the stem is attached to the creeping stolon.

Sertularia megalocarpa is nearly allied to *S. humilis*, whose large gonangia are quite similar in form and origin to those of the present species. In the narrower hydrothecæ, however, of *S. megalocarpa* and their greater freedom from the supporting internode, a distinction of specific value will be found.

Desmoscyphus.

Desmoscyphus orifissus, n. sp. (Pl. XVII. figs. 1–4.)

Trophosome.—Hydrocaulus irregularly branched, set with alternate pinnæ; internodes of pinnæ separated by oblique joints, each internode carrying near its middle one, or occasionally two, pairs of hydrothecæ. Hydrothecæ abruptly swollen at the base, where those of each pair are confluent with one another, then tapering to the distal end; aperture deeply cloven.

Gonosome.—Gonangia borne by the main stem, pyriform, with the aperture terminal, wide, and scarcely raised above the surface of the gonangium.

Locality. Bass's Straits.

This is a very striking form. The hydrothecæ of each pair are closely adnate to one another by their swollen bases, while their distal tapering portions, though diverging to the right and left, are all turned to one side. They thus present a unilateral or secund aspect when viewed in profile, while in a front view they appear to be directed to the right and left. The deeply cleft orifice of the hydrotheca is very striking and characteristic. In most cases but a single pair of hydrothecæ is borne on each internode; but occasionally the internode becomes more elongated and carries two. The species comes near to *Sertularia geminata*, Bale, from which it is distinguished by the swollen bases of the hydrothecæ.

The specimen consisted of a piece of about 2 inches long,

broken from the distal end of a colony, and no evidence of the entire height of the colony could be obtained.

DESMOSCYPHUS UNGUICULATA, Busk*. (Pl. XVII. figs. 5–7.)

Trophosome.—Colony consisting of pinnate stems which spring at short intervals from a creeping filiform stolon; pinnæ alternate. Hydrothecæ with the margin of the orifice produced into a long and wide posterior lip and a much shorter and narrower anterior lip; those of the pinnæ adnate to one another by about two thirds of the height of their opposed sides, those of the stem distinct.

Gonosome.—Gonangia springing each from an internode of the stem; oval, with a circular orifice raised on a very narrow collar.

Locality. Adelaide.

I believe that the hydroid here described must be referred to *Sertularia unguiculata*, Busk. The specimen in the collection is apparently an example of a young colony, and attains a height of somewhat more than half an inch. The two lips into which the margin of the hydrotheca is produced bear some resemblance to the mandibles of a bird. Of these lips the posterior is broad and long and terminates in a blunt point, while the anterior, though nearly of the same shape, is very much smaller, and is hidden by the other in the posterior view of the internode. The internodes of the pinnæ are short, and the consecutive pairs of hydrothecæ are here closely approximate. These hydrothecæ lie entirely on the front of the internode, and in each pair are adnate to one another by the greater part of their opposed sides. The hydrothecæ of the stem also lie upon the front aspect of their internode, but here they are quite distinct from one another.

The stem is divided into internodes carrying each a single pinna, which springs alternately from the right and left in consecutive internodes, or else carrying two alternate pinnæ; the latter condition being chiefly that of the internodes near the base of the stem.

While the disposition of the hydrothecæ of the pinnæ is thus quite that of a typical *Desmoscyphus*, the hydrothecæ of the stem more nearly reproduce the characters of *Thuiaria*.

The specimen extends over the surface of a seaweed, which it thickly covers with a diminutive fern-like growth.

The same species has also been described and figured by Bale†,

* Busk, in Voyage of the 'Rattlesnake.'

† Cat. of Australian Hydroid Zoophytes, p. 76.

from whose account it would seem to be a singularly undefined and heteromorphic hydroid, old specimens combining characters of *Sertularia*, *Thuiaria*, *Selaginopsis*, and *Desmoscyphus*.

Thuiaria.

Thuiaria interrupta, n. sp. (Pl. XVI. figs. 8–10.)

Trophosome.—Stem monosiphonic, carrying pinnately disposed, rather closely-set alternate ramuli. Hydrothecæ borne both by stem and ramuli, nearly opposite, deep flask-shaped, closely set upon the pinnæ in groups of four or five pairs, the groups separated from each other by deep constrictions of the pinna.

Gonosome not present.

Locality. Australia.

This is an easily recognized form, characterized by the distinctly separated groups in which the hydrothecæ are disposed on the pinnæ, and which are quite obvious to the naked eye. The hydrothecæ in each group overlap one another; their margin is thin and collapsable, and it is difficult to obtain from the dried specimen a satisfactory view of it. It would seem, however, to have two small lateral teeth.

The stem is cylindrical, carrying two rows of subopposite, entirely separate hydrothecæ. A narrow, but well-marked joint is present just below the origin of every pinna, and the stem is marked in its entire length by close delicate longitudinal sulci. Each pinna commences by a very short, narrow, cylindrical joint, which is supported by a projecting process of the stem.

The stem attains a height of about 3 inches.

Thuiaria diaphana, *Busk in litteris*, n. sp. (Pl. XVIII. figs. 1–3.).

Trophosome.—Colony attaining a height of 9 inches; stem strongly fascicled towards the base, becoming monosiphonic distally, irregularly branched, and set along its length with close pinnately disposed alternate ramuli. Hydrothecæ alternate, closely set, deep, nearly cylindrical, adnate for their entire height to the internode, and with an even circular orifice, four pairs usually carried on an internode.

Gonosome.—Gonangia carried along one side of the pinnæ, cylindrical, with the summit abruptly truncated, and the margin of the orifice very slightly everted; walls of the gonangium with shallow longitudinal plication.

Locality. Moreton Bay, Queensland.

This beautiful species is remarkable for the delicacy and

transparency of its chitinous periderm and for its large cylindrical plicated gonangia, which in the specimen examined were profusely developed along the upper side of the pinnæ. The contents of the gonangium were always accumulated as an opaque brown mass in the top of its cavity; the plication of its walls was here most distinctly marked, and before reaching the base became obliterated. The species has been examined by Mr. Busk, but not previously described.

THUIARIA RAMOSISSIMA, n. sp. (Pl. XVIII. figs. 4, 5.)

Trophosome.—Hydrocaulus monosiphonic, main stem sending off in every direction branches which are themselves profusely branched; ramification subdichotomous, each bifurcation preceded by a transverse joint. Hydrothecæ alternate, adnate to the hydrocaulus by the whole of their epicauline walls, deep, tubular; the apocauline margin of aperture deeply cleft.

Gonosome.—Gonangia springing each from a point placed laterally just below the base of a hydrotheca; none mature in the specimen.

Locality. North-east coast of America.

The profuse ramification and beautifully plumose disposition of the branches constitute a striking feature in this fine species. In the dried specimen the main stem is brown, while the branches are of a remarkable pale green. The specimen, which is somewhat more than 2 inches in length, has been broken off from the distal end of the colony, and we have no exact data for determining the actual height attained by the species. Some gonangia, too young to allow of the characterization of the mature form, were present in the specimen, where they sprung each from a point just below the base of a hydrotheca.

THUIARIA HIPPISLEYANA, n. sp. (Pl. XIX. figs. 1–3.)

Trophosome.—Stem simple, monosiphonic, set with pinnately disposed, opposite, unjointed ramuli along nearly its entire length. Hydrothecæ borne both by stem and pinnæ, deep, nearly cylindrical, adnate to stem and pinnæ for their entire height, alternate and closely set on the pinnæ, nearly opposite and more distant on the stem, marked towards the base with longitudinal undulating and prominent striæ; margin of orifice crenate, and with a deep sinus at its epicauline side.

Gonosome not known.

Locality. Australia.

This is a beautiful and well-marked form. It attains a height

of upwards of 6 inches. Its pinnæ are long, exceeding towards the proximal end of the stem an inch in length. They are further remarkable in being opposite instead of alternate, and present the still more exceptional character of being quite destitute of joints. While the hydrothecæ of the pinnæ are alternate, those of the stem are opposite, or nearly so, and are more distant than those of the pinnæ.

The stem is marked along its entire length by prominent longitudinal parallel striæ, which present a somewhat interrupted or beaded appearance. These striæ are continued along the pinnæ, where, however, they are less distinct. From the pinnæ they are further continued for some distance along the apocauline side of the hydrothecæ, giving to these when seen in profile a rugose appearance towards the base. The stem differs from the pinnæ in presenting a few joints at wide and variable intervals.

THUIARIA HETEROMORPHA, n. sp. (Pl. XX. figs. 1–5.)

Trophosome.—Stems simple, monosiphonic, springing from a plexus of creeping fibres, closely set with regular alternate pinnæ, each of which has its proximal internode small, spatuliform, and destitute of hydrothecæ. Internodes of stems carrying each three or four pairs of subopposite hydrothecæ, which are nearly cylindrical, with the orifice destitute of teeth and directed obliquely forward, widely separated from one another transversely, and adnate to the internode by the whole of their posterior side. Hydrothecæ of pinnæ opposite but in other respects variable—two, three, or four pairs being borne by an internode in some pinnæ, in others only one; hydrothecæ of every pair on some internodes connate to one another by their opposed sides, in others separate.

Gonosome not known.

Locality. Tasmania.

The species here described is full of significance in its bearing on the question of the definitiveness of systematic characters; for the disposition and form of the hydrothecæ vary in different parts of one and the same colony to an extent which, if noticed in separate colonies, would be regarded as affording grounds for generic distinction. In fact the very characters which are here associated do occur separately in other Sertularian hydroids, and have been made the distinguishing marks of no fewer than three genera, *Thuiaria*, *Desmoscyphus*, and *Sertularia*.

The main stem, which attains a height of about an inch and a half, is throughout that of a typical *Thuiaria*, not only in the

great extent to which the hydrothecæ are adnate to the internodes, but in the disposition of the joints by which numerous hydrothecæ are borne on each side of a single internode. The same condition is presented by many of the pinnæ, each internode carrying two or three pairs of hydrothecæ which are quite separate from one another, but adnate in their entire height to the sides of the internode.

In other pinnæ, however, the hydrothecæ of each pair are brought to one side of the supporting internode, and instead of being distinct, are closely approximate and adnate to one another by their opposed sides. This is the essential character of the genus *Desmoscyphus*, which is thus distinguished from *Thuiaria*.

Further, many pinnæ which are typically Thuiarian in their proximal portion, lose all trace of Thuiarian characters towards their distal extremities, and here carry on each internode a single pair of distinct hydrothecæ. These internodes with their hydrothecæ are in every respect those of a typical *Sertularia*. The orifice, moreover, instead of being nearly circular and even and directed away from the supporting internode, as in the other hydrothecæ of the colony, is here directed towards the internode, and has its apocauline margin produced into a sharp, slightly incurved tooth, and the internode with its pair of opposite hydrothecæ has the V-shaped form which is so general among the Sertulariæ, the proximal portion rapidly narrowing to its point of union with the internode which precedes it. Indeed, the resemblance of each internode with its pair of hydrothecæ in this part of the colony to those of the *Sertularia operculata* of our own coasts is singularly striking.

Amid systematic characters pointing in so many different directions, it would seem difficult to decide on the true generic position of our Hydroid. It may possibly be urged that this singular combination of characters would justify its reference to an entirely new genus; and, indeed, if we could be sure that the features thus presented were constant, this would perhaps be the proper course to adopt. Until, however, the examination of a greater number of specimens shall afford evidence of the constant recurrence of the same combination of characters, I believe it will be better to refer it to one of the three genera represented by it; and as the characters of *Thuiaria* appear to be predominant, I shall content myself with regarding it simply as a very aberrant species of that genus.

The features here noted in *Thuiaria polymorpha* bring to mind a phenomenon not unknown in the vegetable kingdom; as in the case of certain epiphytical orchids, in which flowers whose difference of form is such as to have caused them to be regarded as characterizing so many distinct genera, are nevertheless found associated in one and the same plant.

THECOCLADIUM, nov. gen.

GENERIC CHARACTER *Trophosome.*—Branching stems set with disjunct hydrothecæ, and jointed at distant and uncertain intervals. Branches having their origin within the hydrothecæ. *Gonosome.*—Gonangia ovate vesicles borne along the stems and branches *.

The genus *Thecocladium* comes near to *Thuiaria*, with which it agrees in the indefinite length of its internodes. It differs from it in the very remarkable origin of the branches which invariably spring from within the hydrothecæ and extend through their orifice.

THECOCLADIUM FLABELLUM, n. sp. (Pl. XIX. figs. 4, 5.)

Trophosome.—Colony composed of several simple or branched monosiphonic stems, which arise at short intervals from a non-adherent stolon. Hydrothecæ alternate, adnate to the stem by somewhat more than three fourths of their epicauline walls, cylindrical, curving gently forwards; orifice entire, margined by a membranous rim; two or three pairs of hydrothecæ borne by an internode.

Gonosome not present.

Locality ?

The short, somewhat robust stems, which on the specimen attain a height of about 1 inch, carry deep cylindrical hydrothecæ, slightly turgid at the base. These curve gently forwards, and present a perfectly even circular orifice. The orifice is surrounded by a broad ring-like membranous rim.

A remarkable feature of the present species is the existence of a delicate chitinous annular diaphragm, which intersects the hydrotheca obliquely, passing from about the middle point of the anterior wall downwards and backwards to a point on the posterior wall a little above the base of the hydrotheca. I am

* No gonosome was present in the specimen contained in Miss Gatty's collection; and the character here given is derived from an example of this genus collected during the voyage of the 'Challenger.'

unable to offer any suggestion as to the significance of this very exceptional condition. Its position is nearly that of the intrathecal ridge in the Statoplean Plumularidæ.

Aglaophenia.

Aglaophenia chalarocarpa, n. sp. (Pl. XXI. figs. 1–4.)

Trophosome.—Stem monosiphonic, simple, springing from a tubular stolon at such short intervals as to form a dense tuft. Hydrothecæ rather wide, margin with nine teeth; intrathecal ridge distinct, passing quite round the hydrotheca; mesial nematophore adnate to about three fourths of the height of the hydrotheca, and then terminating in a free process which does not extend beyond the level of the hydrotheca-margin; lateral nematophores strong, cylindrical, reaching the level of the hydrotheca-margin.

Gonosome.—Corbula rather short, with about eight pairs of leaflets, which are but slightly adherent to one another, the rhachis carrying a spur-like nematophore at the base of every leaflet; peduncle of corbula carrying a single hydrotheca.

Locality. Cape of Good Hope.

The species here described attains a height of about one inch, and occurs in dense masses along with *Sertularia aperta* on one of the olive-coloured seaweeds, and is probably an inhabitant of quite shallow water. The leaflets of the corbula are either quite free, or slightly adherent to one another by their opposed edges towards the base.

Aglaophenia perforata, n. sp. (Pl. XXI. figs. 5–8.)

Trophosome.—Stem simple, monosiphonic, springing at intervals from a creeping stolon. Hydrothecæ wide, margin with about five teeth on either side, and a single mesial tooth in front; intrathecal ridge strong, transverse, situated at the junction of the middle and posterior third of the hydrotheca; mesial nematophore adnate to about the posterior third of the hydrotheca, and then terminating in a short free process which is separated from the adnate portion by an imperfect septum; lateral nematophores scarcely overtopping the hydrotheca.

Gonosome.—Corbula closed, deep and rather short, with about nine pairs of costæ; sutures of costæ with a wide aperture between every two denticles; peduncle short, carrying a single hydrotheca.

Locality. St. Vincent Islands.

This is a very minute species, not exceeding a fourth of an inch in height. The internodes of the pinnæ are easily bent on one another, giving the impression of a movable joint between every two hydrothecæ. The corbulæ are disproportionately large for the minute trophosome, and are rendered remarkable by the line of apertures along each suture. These apertures are caused by the imperfect juncture of the sutures, and are so situated that one occurs between every two denticles.

The specimen was found creeping over a piece of gulf-weed.

AGLAOPHENIA ACUTIDENTATA, n. sp. (Pl. XXII. figs. 1–4.)

Trophosome.—Stem irregularly branched, monosiphonic, springing in a crowded tuft from an entangled mass of tubular filaments. Hydrothecæ deep, widening from below upwards, margin with nine strongly marked teeth; intrathecal ridge distinct, extending round the walls of the hydrotheca at a short distance above the base; mesial nematophore adnate to the lower two thirds of the hydrotheca, and then continued to the level of the margin as a thick cylindrical process; lateral nematophores ovoid, short and wide, not overtopping the hydrotheca.

Gonosome.—Corbula entirely closed, short and deep, with about nine coalesced costæ, each having a spur-like denticle at its base; the peduncle carrying a single hydrotheca.

Locality ?

The present species attains a height of about 2 inches, and differs but little from the typical *Aglaopheniæ*. It may be known, however, by its deeply-cut hydrotheca-margin and its short thick corbula. Indications of an imperfect septum may be seen in the mesial nematophore near its distal extremity. The denticles of the costæ of the corbula are cup-shaped with emarginate orifice, and exhibit very clearly the relation of these bodies to true nematophores. The spur-like nematophore at the base of each costa is well marked.

AGLAOPHENIA LATE-CARINATA, n. sp. (Pl. XXIII. figs. 5, 6.)

Trophosome.—Stem simple, monosiphonic, springing at intervals from a delicate creeping stolon; pinnæ alternate, borne each by a strong process of the stem, the supporting process carrying a strong spine and having a similar spine just below it. Hydrothecæ deep, with the margin deeply cleft into eight teeth, the anterior mesial tooth being bifid; a broad keel extending along the front of the hydrotheca from its margin to the mesial nemato-

phore; intrathecal ridge strongly marked, running round the hydrotheca at the junction of its lower and middle third; lateral nematophores not overtopping the hydrotheca; mesial nematophore adnate to somewhat less than the lower third of the hydrotheca, then meeting the keel and ending as a short free process.

Gonosome not known.

Locality. Gulf of Mexico.

The present very minute species, which scarcely exceeds a fourth of an inch in height, was found creeping over gulf-weed. Its strong intrathecal ridge gives to the hydrotheca a decidedly bithalamic character, indicated even externally by a slight constriction at the level of the ridge. The two spine-like processes which lie at the distal end of every pinna are probably modified nematophores. It is nearly allied to the equally minute *Aglaophenia perpusilla* of the United-States Exploration of the Gulf-Stream. It differs, however, from *A. perpusilla* by the greater width of the keel, and by the greater depth of the hydrotheca, and the more strongly marked intrathecal ridge. No gonosome was present in either species.

I have obtained *Aglaophenia late-carinata* from other collections of gulf-weed. It appears indeed to be quite a characteristic form of the hydroid fauna of the floating Sargasso field of the North Atlantic.

AGLAOPHENIA DOLICHOCARPA, n. sp. (Pl. XXIV. figs. 1–4.)

Trophosome.—Stem simple or very sparingly branched, monosiphonic; hydrocladia alternate, closely set, and with short internodes. Hydrothecæ conical, with the margin slightly everted and having four teeth on each side, and one mesial tooth in front; the anterior of the four lateral teeth is strong and furcate, the posterior long and pointed, and the intermediate two teeth short and blunt; intrathecal ridge strong, situated near to the fundus of the hydrotheca; mesial nematophore adnate to the hydrotheca-walls for the entire height of the walls, and with its free terminal portion short and truncate; lateral nematophores wide, scarcely overtopping the hydrotheca.

Gonosome.—Corbula completely closed, very long, cylindrical, composed of about twenty costæ.

Locality. Australia.

The most characteristic feature of this beautiful species, which attains a height of about 6 inches, will be found in the very

long cylindrical corbula. This possesses about twenty costæ, each of which carries about seven denticles and has a short blunt spur at its base. Indications of an intracostal septum may be seen in a broad line which extends in each costa from a point near its base to within a short distance of its summit. The peduncle of the corbula carries two hydrothecæ. Another striking feature consists in the peculiar denticulation of the hydrotheca-margin, with its broad furcate tooth on each side in front, and long pointed tooth behind. The hydrocladial internodes are short, and the hydrothecæ in consequence closely approximated.

Halicornaria.

Halicornaria mitrata, n. sp. (Pl. XXII. figs. 5, 6.)

Trophosome.—Stem fascicled, irregularly branched, becoming monosiphonic towards the distal extremities of the branches. Hydrothecæ with a deep constriction in front at a short distance below the margin; margin with a broad angular lobe on each side, and a long, strong, curved, spine-like tooth in front; intrathecal ridge well marked, situated at the junction of the middle and posterior thirds of the hydrotheca-walls; mesial nematophore forming a broad strong process adnate to the hydrotheca as high as the constriction below the margin, and then becoming free and attaining about the height of the distal end of the anterior marginal spine; lateral nematophores strong, cylindrical, attaining the level of the points of the marginal lobes of the hydrothecæ.

Gonosome not known.

Locality?

The present species attains a height of nearly 6 inches. The hydrotheca, with its two-lobed margin and strong anterior spine-like tooth, the deep constriction below the margin, and the very broad and long mesial nematophore afford an assemblage of characters by which this remarkable species may be at once distinguished. It is probably correctly referred to *Halicornaria*, though in the absence of gonosome this determination cannot be regarded as otherwise than provisional.

Halicornaria cornuta, n. sp. (Pl. XXIII. figs. 1–4.)

Trophosome.—Stem simple, monosiphonic, springing at short intervals from a network of creeping filaments. Hydrothecæ deep, rapidly narrowing towards the base and with the axis directed obliquely forward; margin with two broad, somewhat

everted teeth on each side, and a single long tooth-like process springing from the middle point of the back; mesial nematophore adnate to the hydrotheca-walls for their entire height, then forming a free laterally compressed process which bends upwards at a right angle, carrying on its posterior edge an elevated round orifice, and ending in a long pointed spine; lateral nematophores pyriform, with the upper edge of the orifice continued into a long horn-like spine.

Gonosome not known.

Locality?

This is a very remarkable species. It attains a height of about 4 inches, and is rendered especially striking by its singularly shaped mesial and lateral nematophores. The round orifice, raised on the summit of a papilliform projection of the posterior edge of the mesial nematophore, must, I believe, be regarded as indicating the true summit of the nematophore, its spine-like continuation beyond this point being apparently imperforate. Just below this orifice is a small tooth-like process, which is given off from the nematophore on a level with the margin of the hydrotheca. The lateral nematophores are also continued each into a long slightly curved spine, which gives to the hydrotheca when viewed in front the appearance of being surmounted by two long horns. It is generally, however, only towards the distal extremity of the pinnæ that these horn-like spines can be seen in perfection; near the base of the pinnæ they appear to be stunted or broken off.

In the absence of a gonosome, the reference of this species to *Halicornaria* is provisional.

Lytocarpus.

Lytocarpus ramosus, n. sp. (Pl. XXV. figs. 1–3.)

Trophosome.—Stem fascicled, much and irregularly branched. Hydrothecæ deep, somewhat ventricose, margin with about nine strong teeth, intrathecal ridge a little below the middle of the hydrotheca; mesial nematophore adnate to about the lower three fourths of the hydrotheca, and then extending as a free strong spine to a level with the margin; lateral nematophores slightly overtopping the hydrotheca.

Gonosome.—Phylactocarps developed at irregular intervals along the branches, and consisting of a rhachis with about thirty-

two alternate costæ; costæ arching over the rhachis from opposite sides, and each carrying several pairs of strong opposite spines.

Locality. Bass's Straits.

This is a tall, strong-growing species, attaining a height of about 9 inches. The pinnæ spring very decidedly from the anterior aspect of the branch, each internode of the branch carrying a single pinna directed alternately to the right and left. A large nematophore is borne by each internode just above the origin of the pinna.

The phylactocarps are very beautiful objects. They are formed on the type of the phylactocarps of *Lytocarpus* (*Aglaophenia*) *myriophyllum*. The rhachis is composed of about thirty-two internodes, each internode supporting a single costa, the costæ springing alternately from the right and left sides of the internodes, where each forms a continuation of a short process from the rhachis. To this process it is united by a transverse joint, and besides the pairs of opposite spines it carries near its proximal end a single azygous spine and a pair of short, blunt, closely approximated nematophores. Every internode of the rhachis carries a gonangium, whose point of origin was clearly seen, though the gonangia themselves had all fallen from the specimen.

GATTYA, gen. nov.

GENERIC CHARACTER. *Trophosome.*—Hydrocaulus consisting of hydrocladia which spring from a creeping stolon or from one another through the intervention of a jointed peduncle, and are divided into distinct internodes, each internode carrying a hydrotheca. Hydrothecæ with dentate margin; mesial nematophore fixed, not adnate to the hydrotheca; lateral nematophores moveable. *Gonosome.*—Gonangia destitute of special protective apparatus.

The genus *Gattya* holds a position intermediate between the typical Eleutheroplean and the typical Statoplean forms of the Plumularidæ. To the former it is connected by its moveable lateral nematophores and by the complete separation of the mesial nematophore from the walls of the hydrotheca. To the latter it is connected by its fixed mesial nematophore, and by the dentate margin of the hydrothecæ. Notwithstanding, however, its obvious relations to the Statoplean Plumularidæ, the presence of moveable nematophores must be held as deciding in favour of its place among the Eleutheroplea.

With the genus *Heteroplon* of the 'Challenger' Expedition it has unmistakable relations in the presence of moveable lateral and fixed mesial nematophores, the mesial nematophores being in both genera separated from the hydrotheca. It differs, however, from *Heteroplon* in its dentate hydrotheca-margin in its non-pinnate ramification, and in its pedunculated hydrocladia.

Gattya humilis, n. sp. (Pl. XXIV. figs. 5–7.)

Trophosome.—Hydrocladia borne along the length of a creeping tubular stolon, from which each springs by a cylindrical jointed peduncle, and occasionally sending off a branch which springs in a similar way from the hydrocladium which carries it; internodes of hydrocladia separated from one another by very distinct joints. Hydrothecæ boat-shaped, adnate to the internode by the whole epicauline wall; aperture with a strong tooth on either side and another in front; no intrathecal ridge; mesial nematophore short, with a wide cup-shaped termination, separated by a short interval from the hydrotheca; lateral nematophores trumpet-shaped, supported on short styloid processes which are given off on a level with the hydrotheca-margin.

Gonosome.—Gonangia pyriform, with broad truncated summit, springing each by a narrow-jointed peduncle from the side of an internode close to the posterior wall of a hydrotheca.

Locality ?

Gattya humilis attains a height of about one fourth of an inch, is the only known representative of its genus, and presents an assemblage of characters in the highest degree remarkable and distinctive. The peduncles of the hydrocladia are cylindrical, equalling in length a hydrothecal internode, about the thickness of the stolon from which they spring, and composed of four or five short annular internodes. Each hydrocladium is usually quite simple. It occasionally, however, sends off a branch, which then entirely resembles the hydrocladium from which it springs, and to which it is connected by a jointed peduncle quite similar to that by which the primary hydrocladium is connected to the stolon.

The form of the hydrotheca is very remarkable. It may be roughly compared to that of a boat, the stern of which is adnate to the supporting internode, while the gunwale carries a pointed process on each side, and the bows are projected into a curved beak.

Plumularia.

Plumularia lagenifera, n. sp. (Pl. XXVI. figs.1–3.)

Trophosome.—Stems simple, springing at very short intervals from a creeping reticulated stolon, each internode giving off a short hydrocladium from alternate sides; hydrocladium with the hydrotheca-bearing internodes separated from one another by several short internodes destitute of hydrothecæ. Hydrothecæ wide and shallow, somewhat ventricose, springing from a point near the middle of the supporting internode, and adnate to the internode by the entire epicauline side; a single mesial nematophore borne by the hydrothecal internode at the proximal side of the hydrotheca and another on one of the intervening internodes.

Gonosome.—Gonangia springing singly from the proximal end of the hydrocladium, oboviform, with the orifice raised on the summit of a tubular neck-like projection, and with the base narrowed into a short peduncle of attachment.

Locality. Vancouver's Island.

Plumularia lagenifera covers the surface of seaweeds with a dense growth of delicate hair-like filaments, which attain a height of about 3 inches.

The specimen was brought by Dr. Harvey from Vancouver's Island.

Plumularia multinoda, n. sp. (Pl. XXVI. figs. 4–6.)

Trophosome.—Colony composed of a cluster of delicate simple or very sparingly branched monosiphonic stems, which are divided by transverse joints into rather short internodes, each sending off a hydrocladium from a point close to its distal end; hydrocladia alternate with the hydrothecal internodes, separated from each other by series of usually five short internodes. Hydrothecæ cup-shaped, wide and shallow, situated near the middle of their supporting internodes, to which they are adnate by the whole of their epicauline side; a single mesial nematophore borne by the hydrothecal internode at the proximal side of the hydrotheca, and another on one of the intervening internodes.

Gonosome.—Gonangia springing each from the side of a cladophore, elongated oviform, with the base tapering into a peduncle of attachment, and with the summit tapering towards an even, circular, everted orifice.

Locality. Tauranga, New Zealand.

This delicate *Plumularia* grows in close tufts of fine plumose filaments which may attain a height of about 2 inches. The short internodes by which the long hydrothecal internodes are separated from one another form usually a series of five, of which the middle one is longer than the two at each end of it, these last being reduced to the condition of mere annuli. It is the middle one which carries the nematophore of this part of the hydrocladium. In its shallow and distant hydrothecæ, and in the series of short intercalated internodes the species approaches *Plumularia lagenifera* of the present collection.

DESCRIPTION OF THE PLATES.

Plate VII.

Figs. 1, 2. Campanularia carduella, n. sp.—1. Natural size; the hydroid creeping over a seaweed. 2. Portion of a colony with gonangium; magnified.

3, 4. Sertularella margaritacea, n. sp.—3. A colony; natural size. 4. Portion of a branch with gonangium; magnified.

Plate VIII.

Figs. 1, 3. Sertularella capillaris, n. sp.—1. Natural size. 2. Portion of a branch with gonangium; magnified. 3. A hydrotheca; still further magnified.

4, 5. Sertularella crassipes, n. sp.—4. Natural size. 5. Portion of a pinna with gonangium; magnified.

Plate IX.

Figs. 1, 2. Sertularella cuneata, n. sp.—1. Natural size. 2. Portion of a pinna with gonangium; magnified.

3, 4. Sertularella limbata, n. sp. 3. Natural size; creeping over a seaweed. 4. Portion of a colony with gonangium; magnified.

Plate X.

Figs. 1, 2. Sertularella trimucronata, n. sp.—1. A colony; natural size; growing on a seaweed. 2. Portion of pinna with gonangium; magnified.

3, 4. Sertularella trochocarpa, n. sp.—3. Portion of a colony; natural size. 4. Portion of a pinna with gonangium; magnified.

Plate XI.

Figs. 1, 2. Sertularella diffusa, n. sp.—1. Natural size. 2. Portion of a colony; magnified.

Plate XII.

Figs. 1, 2. Diphasia bipinnata, n. sp.—1. A colony; natural size. 2. Portion of a pinna with female gonangium; magnified.

3, 4. Synthecium ramosum, n. sp.—3. A colony; natural size. 4. Portion; magnified.

Plate XIII.

Figs. 1, 2. Sertularia aperta, n. sp.—1. A colony; natural size. 2. Portion; magnified.

3, 4. Sertularia minima, D'A. W. Thompson.—3. A colony, natural size, creeping over the surface of a species of *Sargassum*. 4. Portion of a colony with gonangium; magnified.

5–7. Sertularia unilateralis, n. sp.—5. Portion of a colony; natural size. 6. Portion, magnified, with origin of a gonangium. 7. Gonangium; magnified.

Plate XIV.

Figs. 1, 2. Sertularia crinis, n. sp.—1. Natural size. 2. Portion of a colony with gonangium; magnified.

Plate XV.

Figs. 1–6. Sertularia elongata, Lamx.—1. A colony, natural size; form from Tasmania. 2. Proximal end of a pinna, with origin of gonangium; magnified. 3. Gonangium; magnified. 4. Form from West Australia. 5. Proximal end of pinna, with origin of gonangium; magnified. 6. Gonangium; magnified.

Plate XVI.

Figs. 1, 2. Sertularia crinoidea, n. sp.—1. Natural size, growing over a seaweed. 2. Portion of a colony; magnified.

3, 4. Sertularia amplectens, n. sp.—3. Colony, natural size, growing over the surface of floating gulf-weed. 4. Portion of a pinna; magnified.

5–7. Sertularia megalocarpa, n. sp.—5. Natural size, growing over a seaweed. 6. Portion of a colony, with gonangium; magnified. 7. Distal portion of hydrotheca; still further magnified.

8–10. Thuiaria interrupta, n. sp.—8. Colony; natural size. 9. An internode of a pinna; magnified. 10. Portion of stem with origin of two pinnæ; magnified.

Plate XVII.

Figs. 1–4. Desmoscyphus orifissus, n. sp.—1. Natural size. 2. Portion of pinna, lateral view; magnified. 3. Portion of pinna, front view; magnified. 4. Gonangium.

Figs. 5–7. Desmoscyphus unguiculata, Busk.—5. Colony, natural size, growing over a seaweed. 6. Portion of a colony, front view, with gonangium; magnified. 7. An internode carrying a pair of hydrothecæ, back view; magnified.

Plate XVIII.

Figs. 1–3. Thuiaria diaphana, Busk.—Portion of a colony, natural size. 2. Portion of a pinna, front view; magnified. 3. Portion of a pinna, lateral view, with gonangia; magnified.

4, 5. Thuiaria ramosissima, n. sp.—4. Natural size. 5. Portion of a colony with immature gonangium; magnified.

Plate XIX.

Figs. 1–3. Thuiaria Hippisleyana, n. sp.—1. Natural size. 2. Portion of main stem with pinna; magnified. 3. A hydrotheca; still further magnified.

4, 5. Thecocladium flabellum, n. gen. et sp.—4. Portion of a colony; natural size. 5. Portion of a colony with origin of a branch from within a hydrotheca; magnified.

Plate XX.

Figs. 1–5. Thuiaria heteromorpha, n. sp.—1. A colony; natural size. 2. Portion of main stem with proximal ends of two pinnæ, front view; magnified. 3. Proximal end of one of these pinnæ, seen in profile. 4. Proximal end of a pinna from another part of the stem. 5. Portion of a pinna from a point near its distal end.

Plate XXI.

Figs. 1–4. Aglaophenia chalacocarpa, n. sp.—1. Colony; natural size. 2. Hydrotheca, lateral view; magnified. 3. Hydrotheca, front view; magnified. 4. The corbula; magnified.

5–8. Aglaophenia perforata, n. sp.—5. Natural size; growing over a piece of gulf-weed. 6. Portion of a hydrocladium with hydrothecæ; magnified. 7. Corbula; magnified. 8. Portion of suture of two costæ of corbula, showing the apertures between the denticles; still more magnified.

Plate XXII.

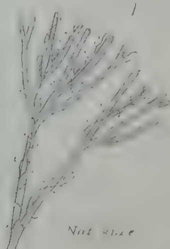
Figs. 1–4. Aglaophenia acutidentata, n. sp.—1. A colony; natural size. 2. Portion of a hydrocladium with hydrothecæ, lateral view; magnified. 3. Hydrotheca, front view; magnified. 4. Corbula.

5, 6. Halicornaria mitrata, n. sp.—5. A colony; natural size. 6. Portion of a hydrocladium with hydrothecæ; magnified.

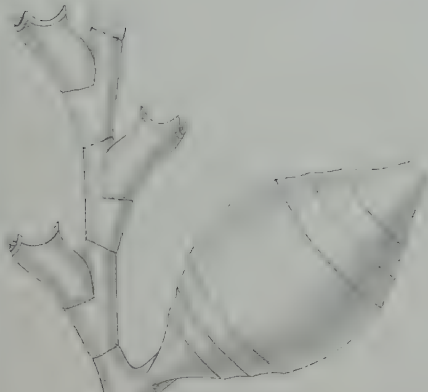
3

Nat. size.

1



Nat. size.



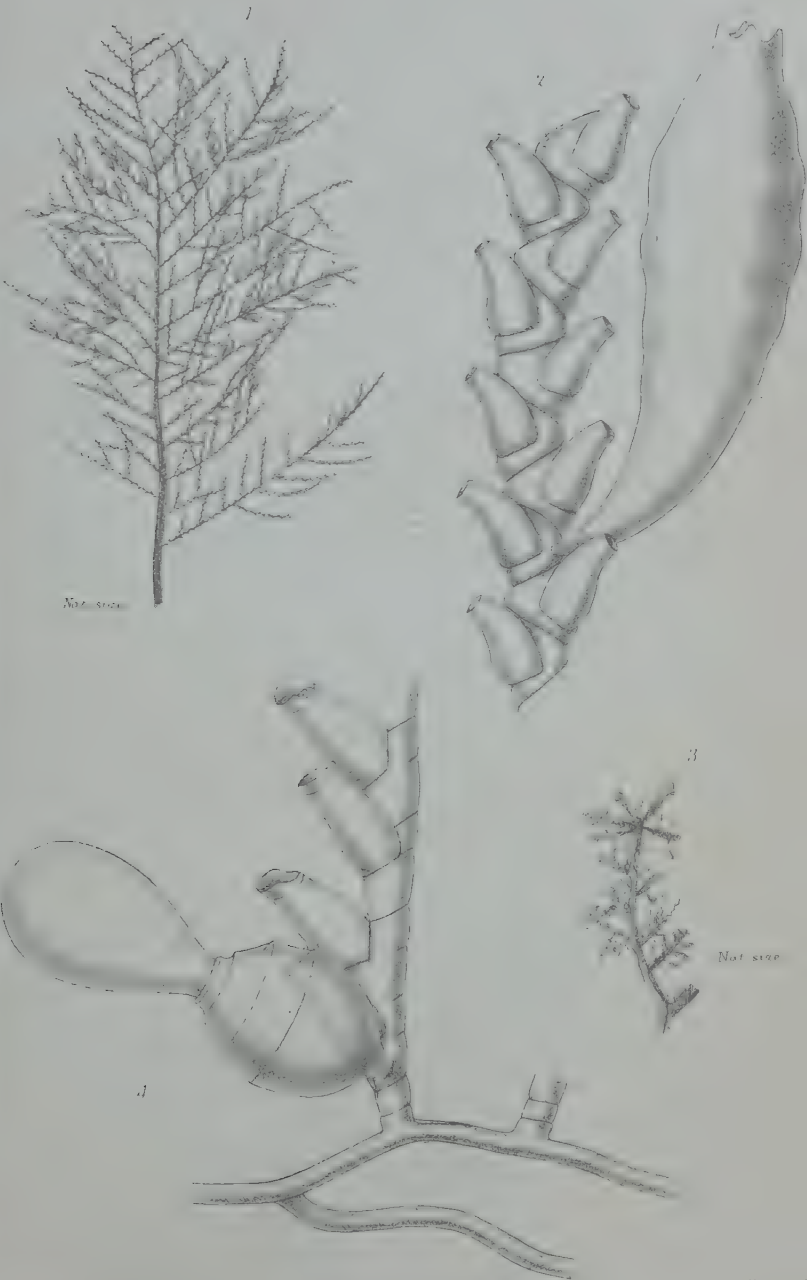
4

2

Holiack lith.

1–2 CAMPANULARIA CARDUELLA, Allm.
3–4 SERTULARELLA MARGARITACEA, Allm.

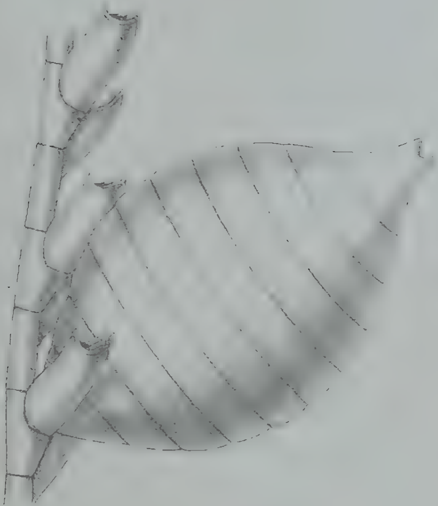
West Newman imp.



Hollick lith. West Newman, imp.

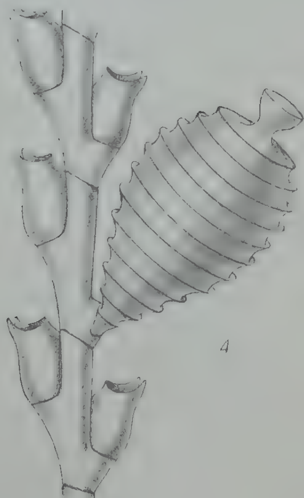
1–2 SERTULARELLA CUNEATA, Allm. 3–4 S. LIMBATA, Allm.

1



3

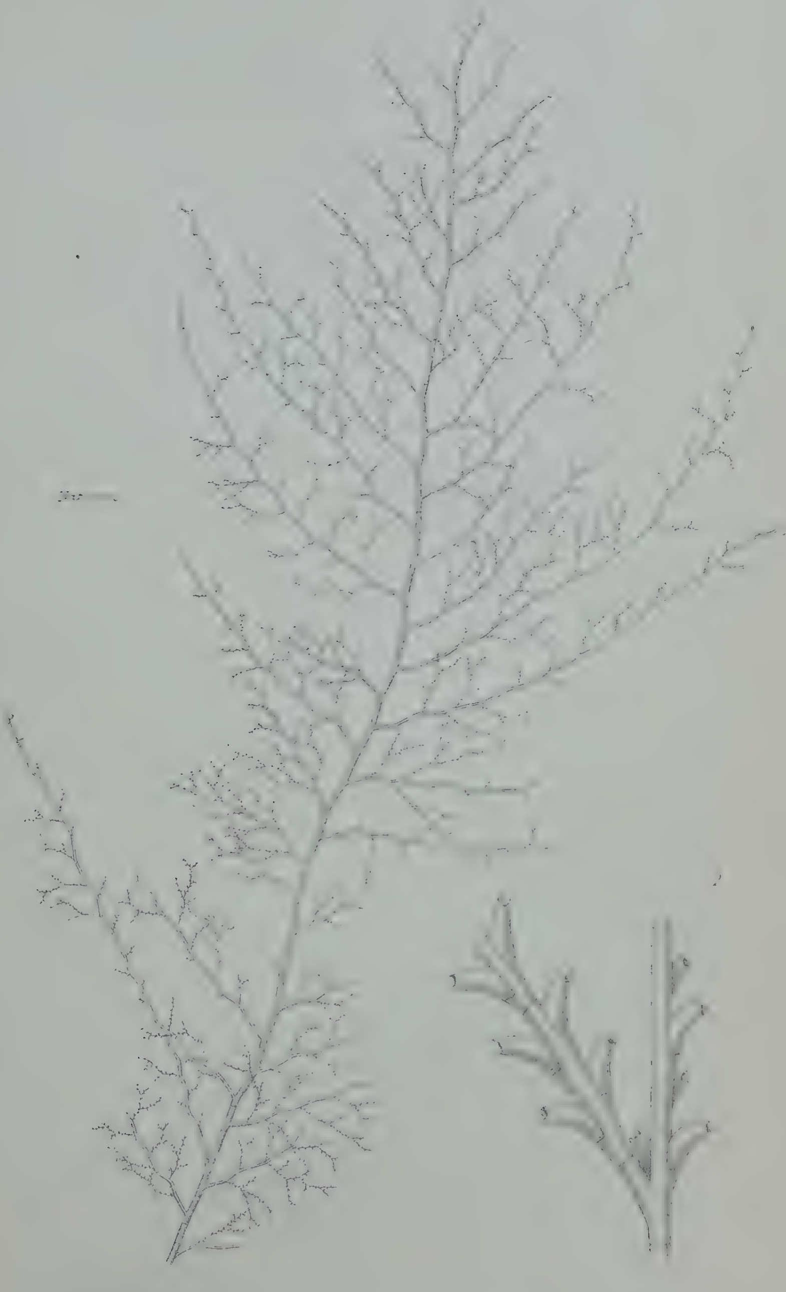
Nat. size.



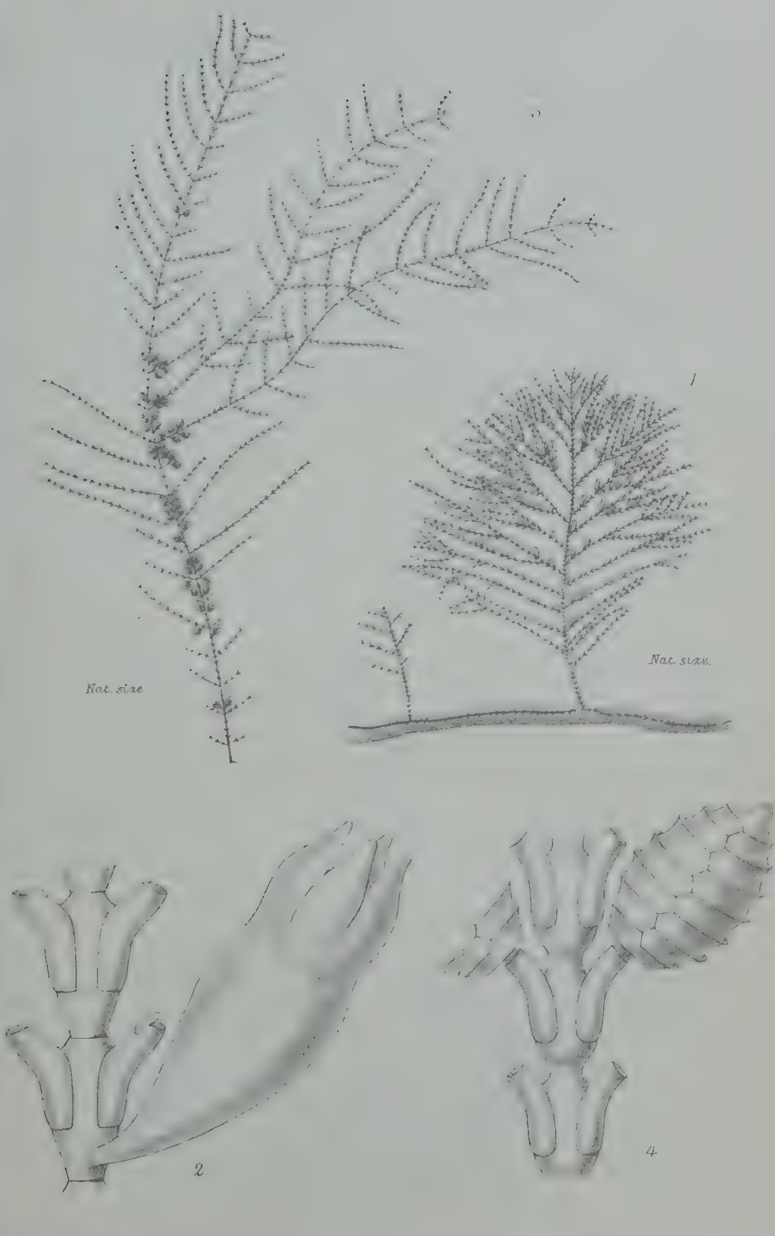
4

1–2 SERTULARELLA TRIMUCRONATA Allm.
3–4 S. TROCHOCARPA, Allm.

Hollick lith. West, Newman, imp.



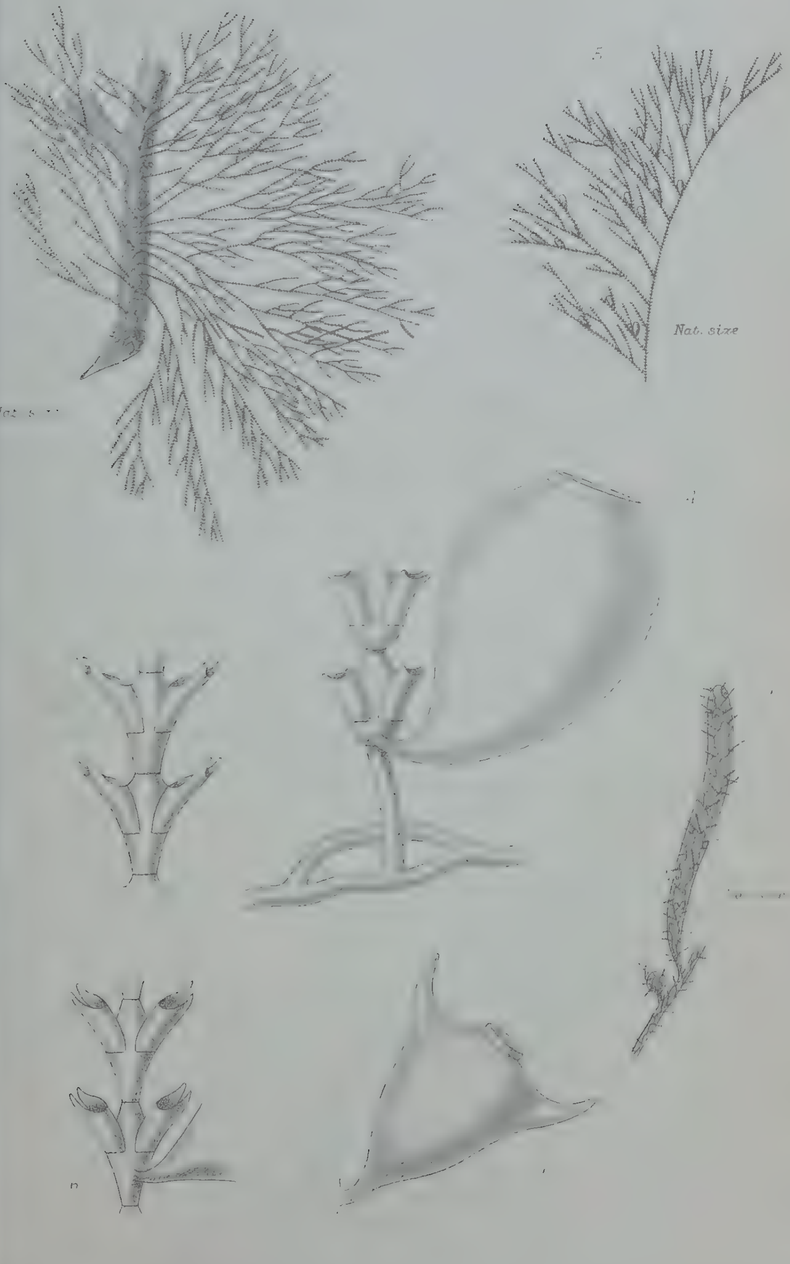
Hollick lith. 1. 2. SERTULARELLA DIFFUSA Allm. West Newman imp.



1–2 DIPHASIA BIPINNATA, Allm.
3–4 SYNTHECIUM RAMOSUM, Allm.

Hollick lith.

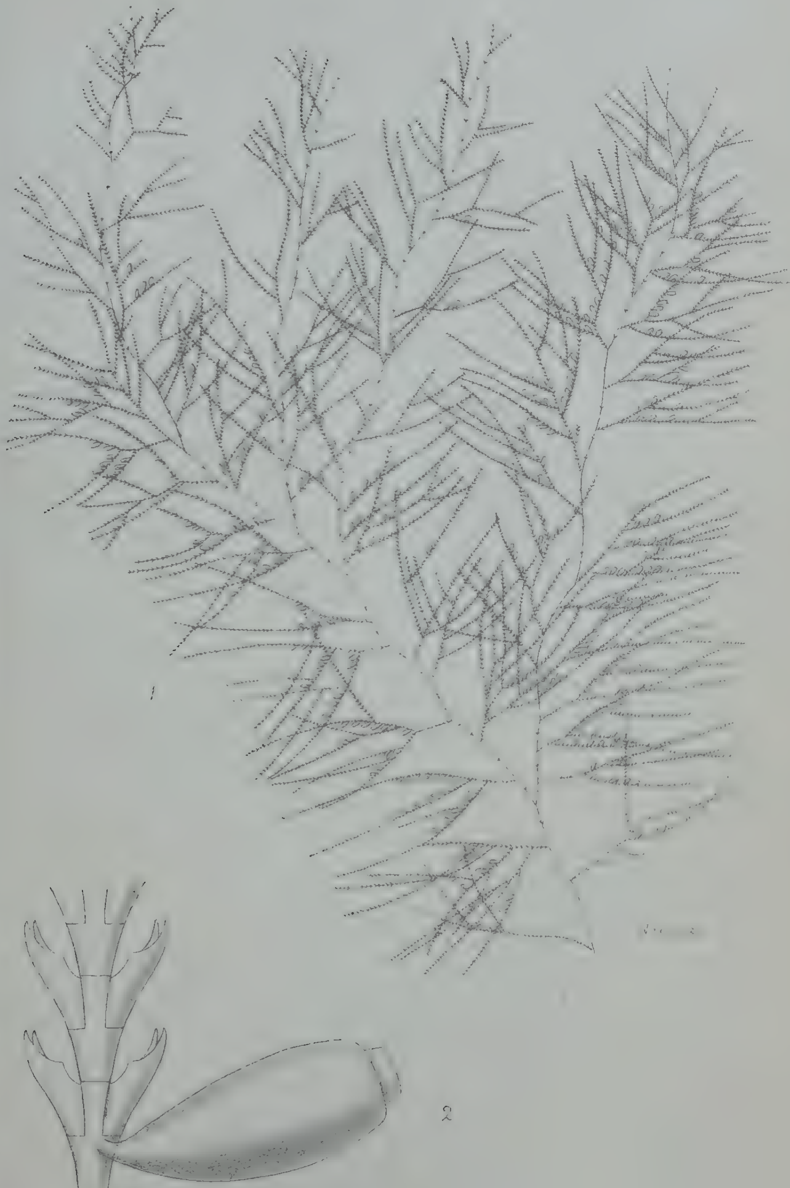
West Newman, imp.



1-2 SERTULARIA APERTA, Allm.

3-4 S. MINIMA Thomp. 5-7 S. UNILATERALIS Allm.

West Newman imp.

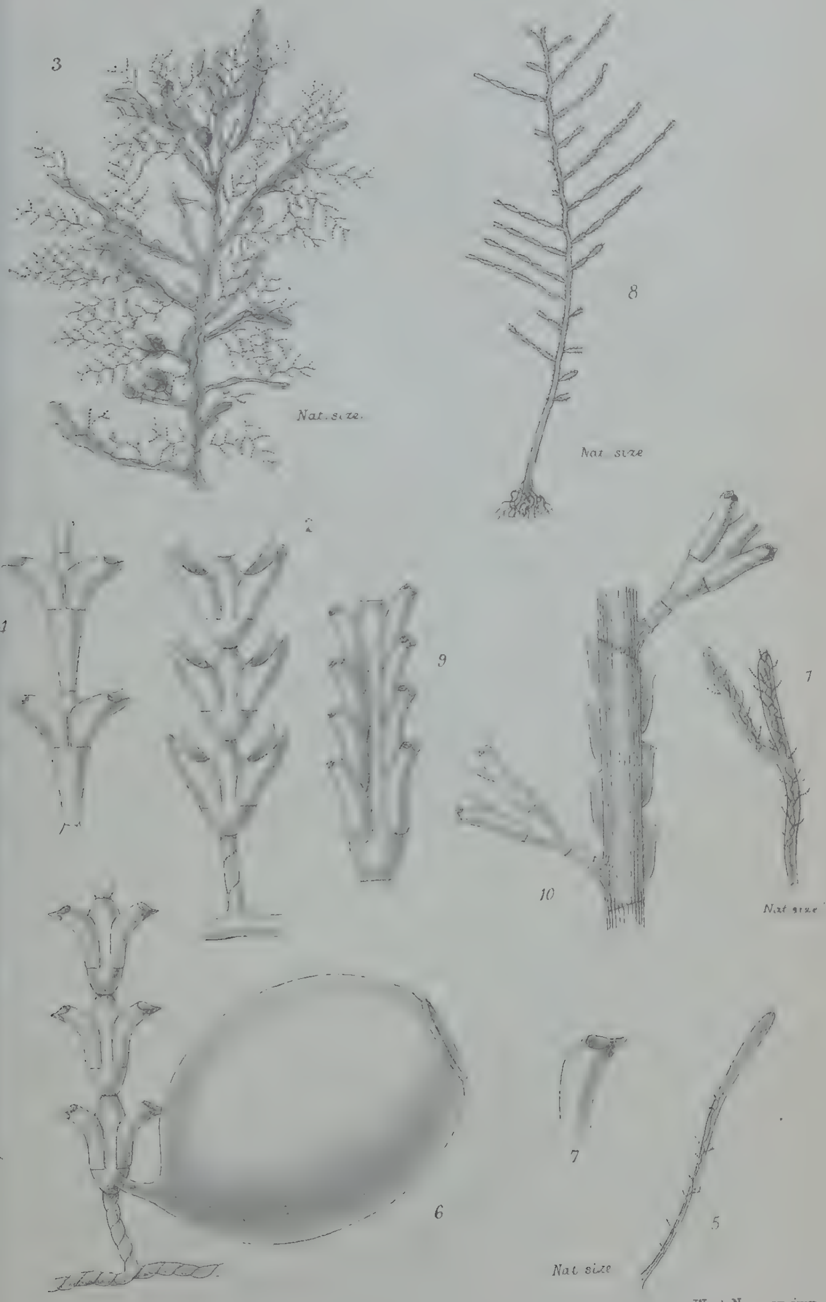


1—2 SERTULARIA CRINIS, Allm.

ck lith

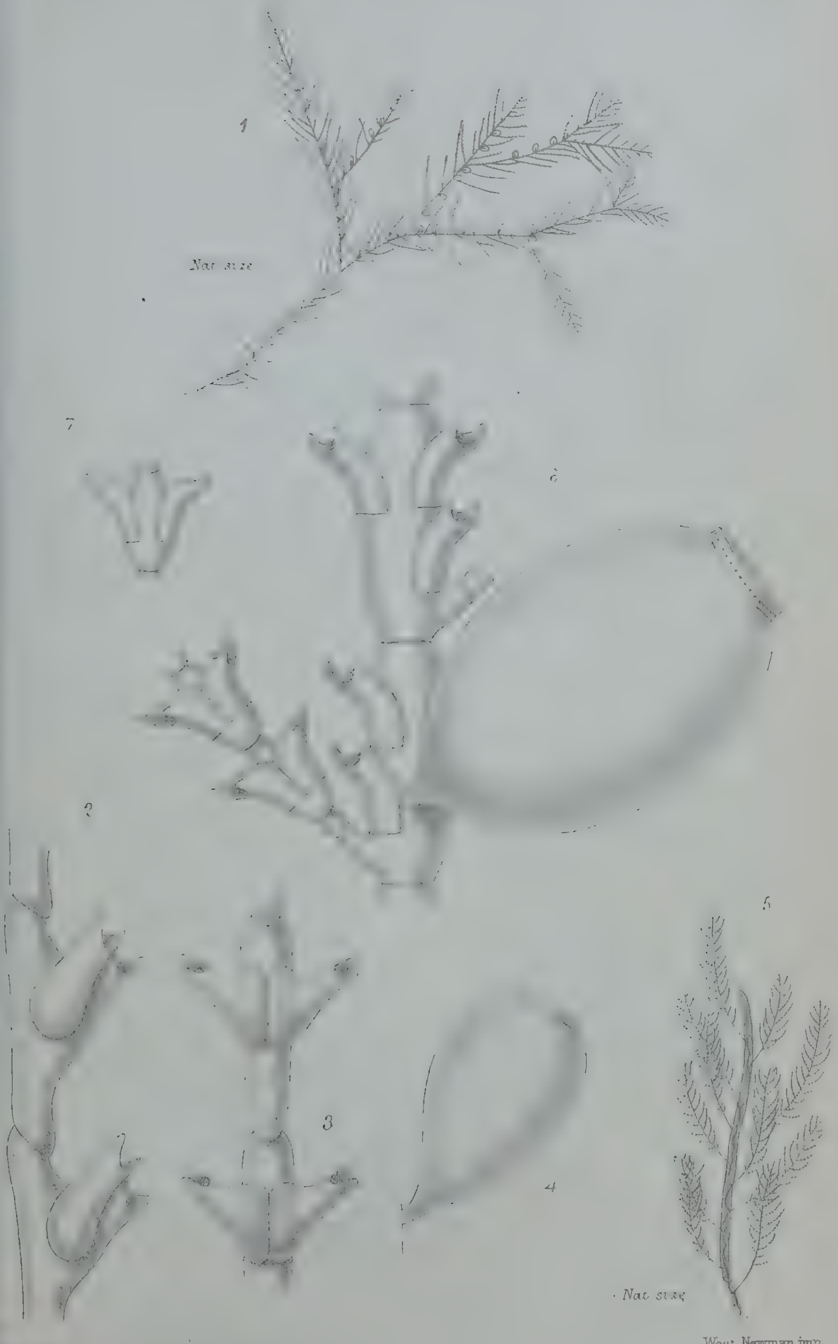
1–6 SERTULARIA ELONGATA, Lamx.

West Newman, imp.



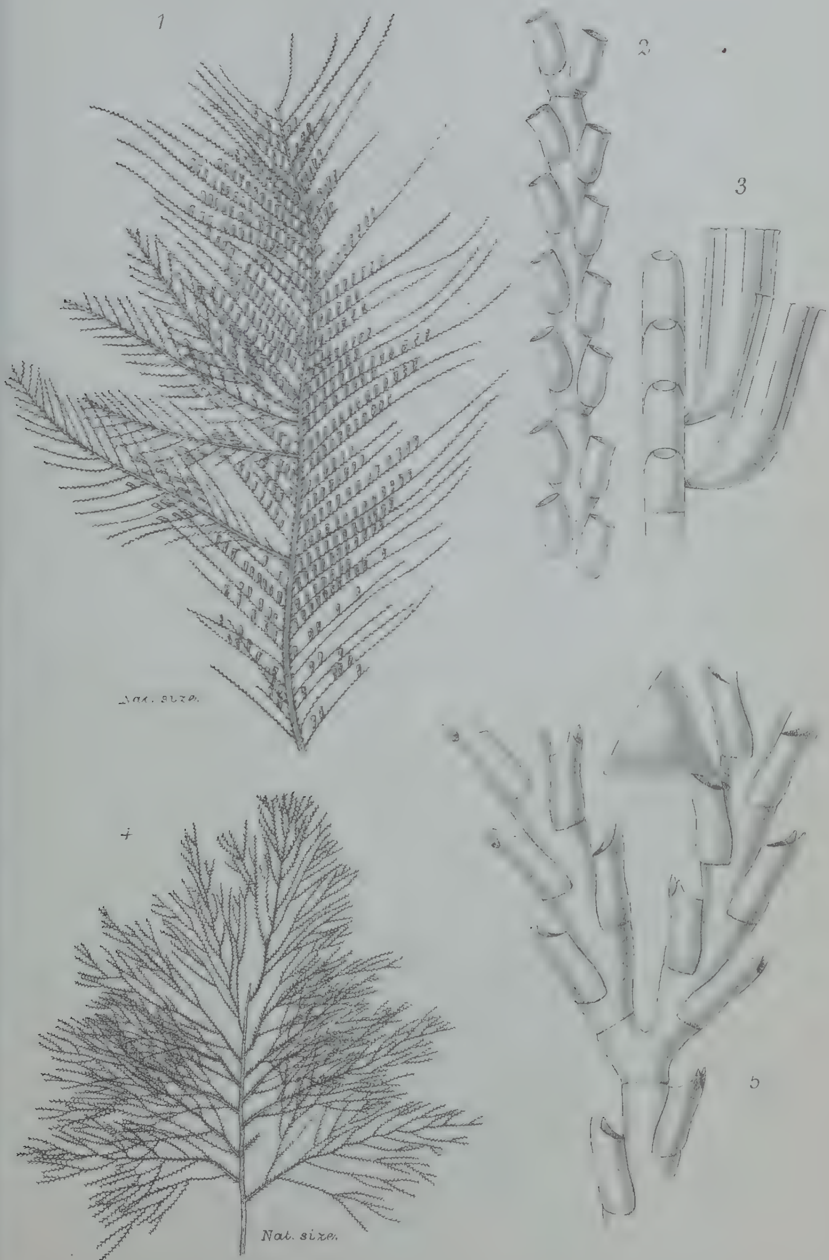
Hollick lith. West Newman, imp.

1–2 SERTULARIA CRINOIDEA, Allm. 3–4 S. AMPLECTENS, Allm
5–7 S. MEGALOCARPA, Allm. 8–10 THUIARIA INTERRUPTA, Allm.



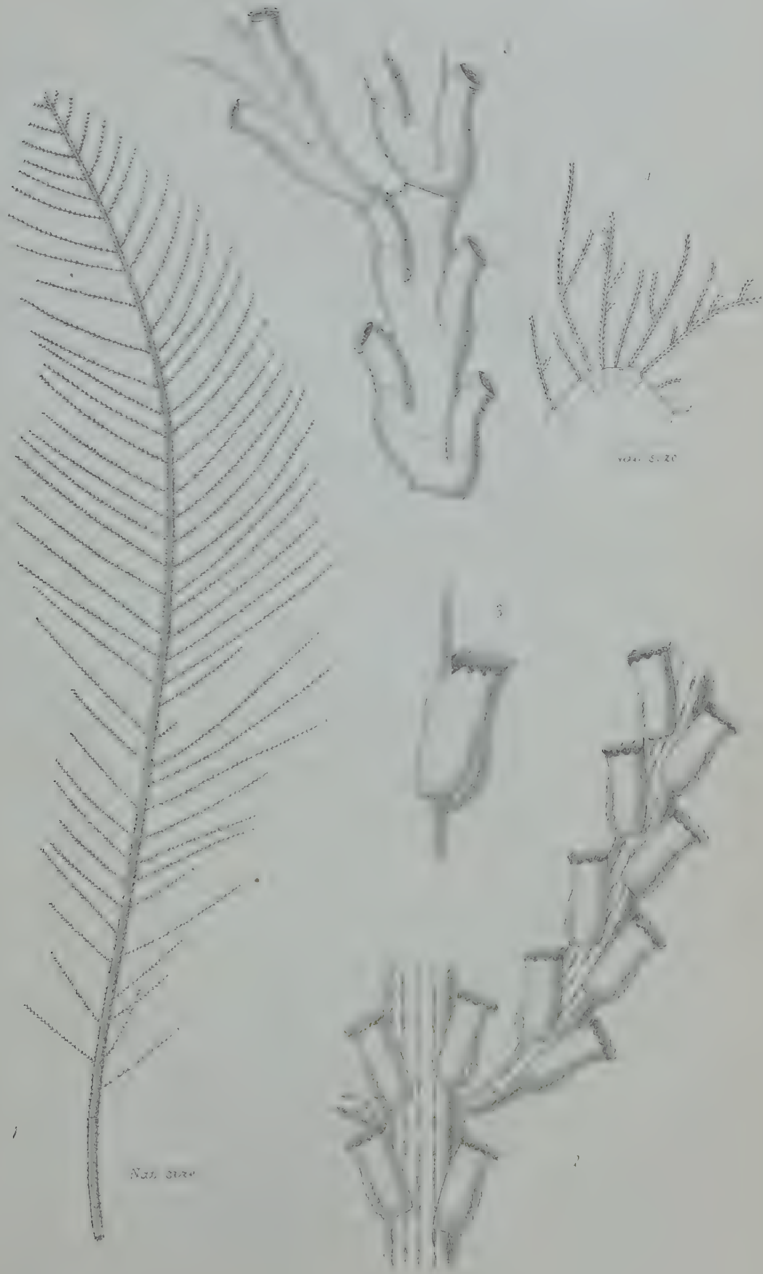
Hollick lith. West Newman, imp.

1–4 DESMOSCYPHUS ORIFISSUS Allm. 5–7 D. UNGUICULATA, Busk.



Hollick lith. West Newman imp.

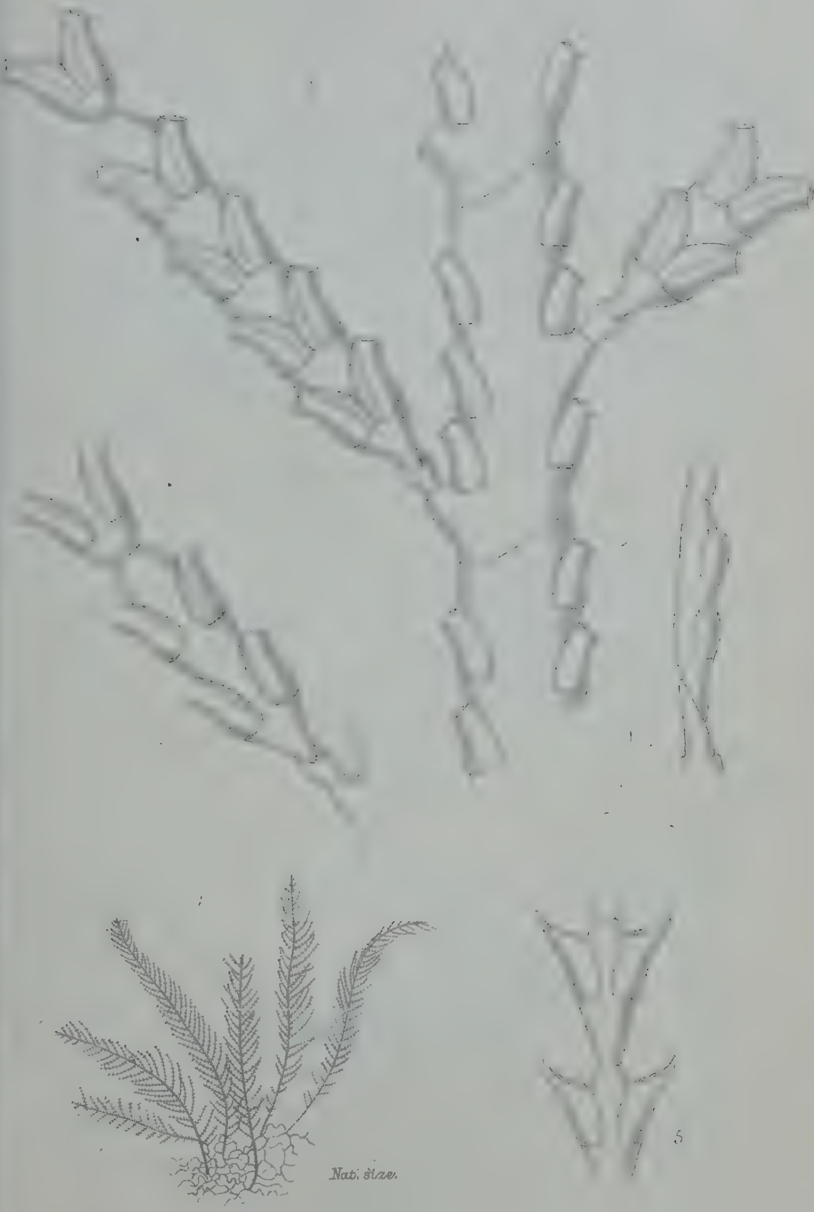
1–3 THUIARIA DIAPHANA, Busk. 4–5 T. RAMOSISSIMA, Allm.



1–3 THUIARIA HIPPISLEYANA, Allm.

4–5 THECOCLADIUM FLABELLUM, Allm.

Hollick lith. West Newman, imp.

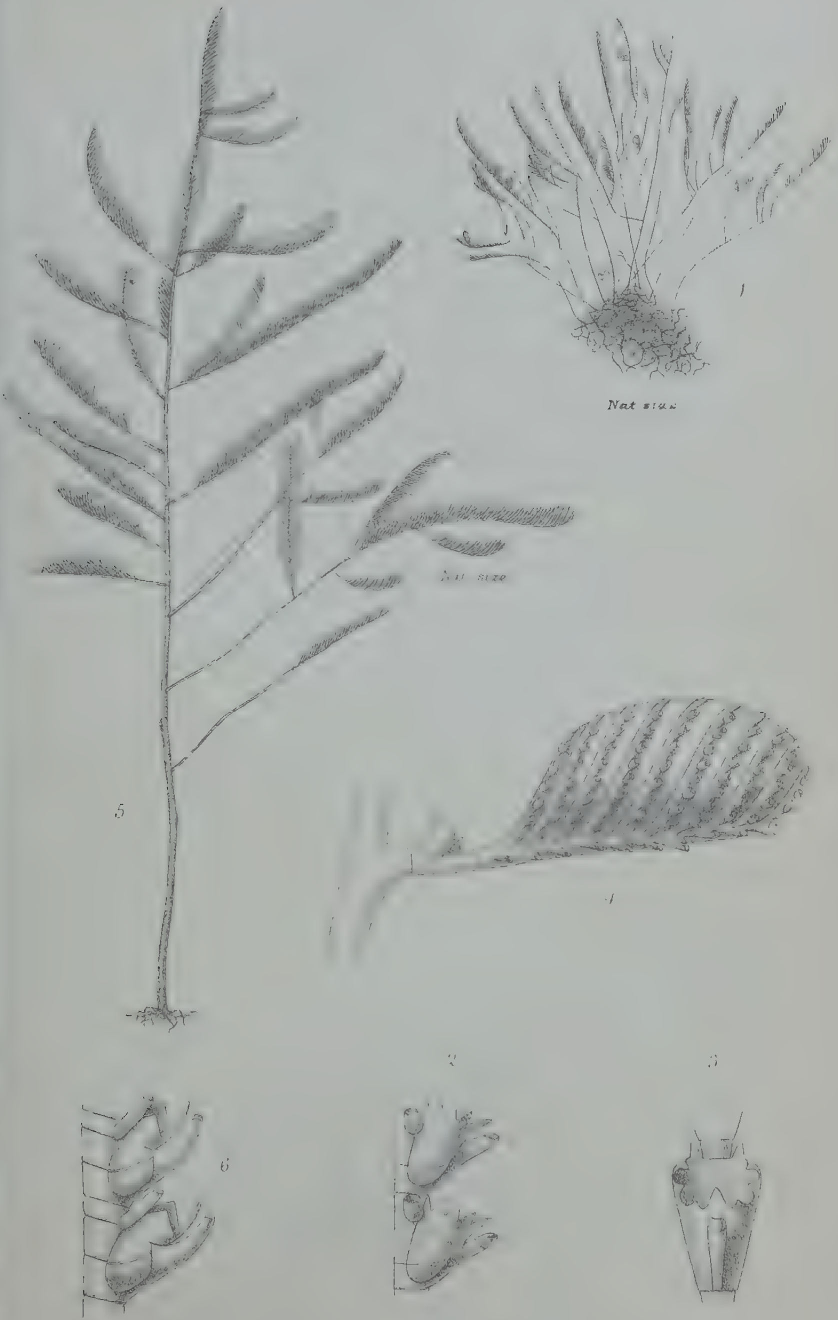


[M]inck lith. 1–5 THUIARIA HETEROMORPHA, Allm. West Newman, imp.

1–4 AGLAOPHENIA CHALAROCARPA, Allm.
5–8 A. PERFORATA, Allm.

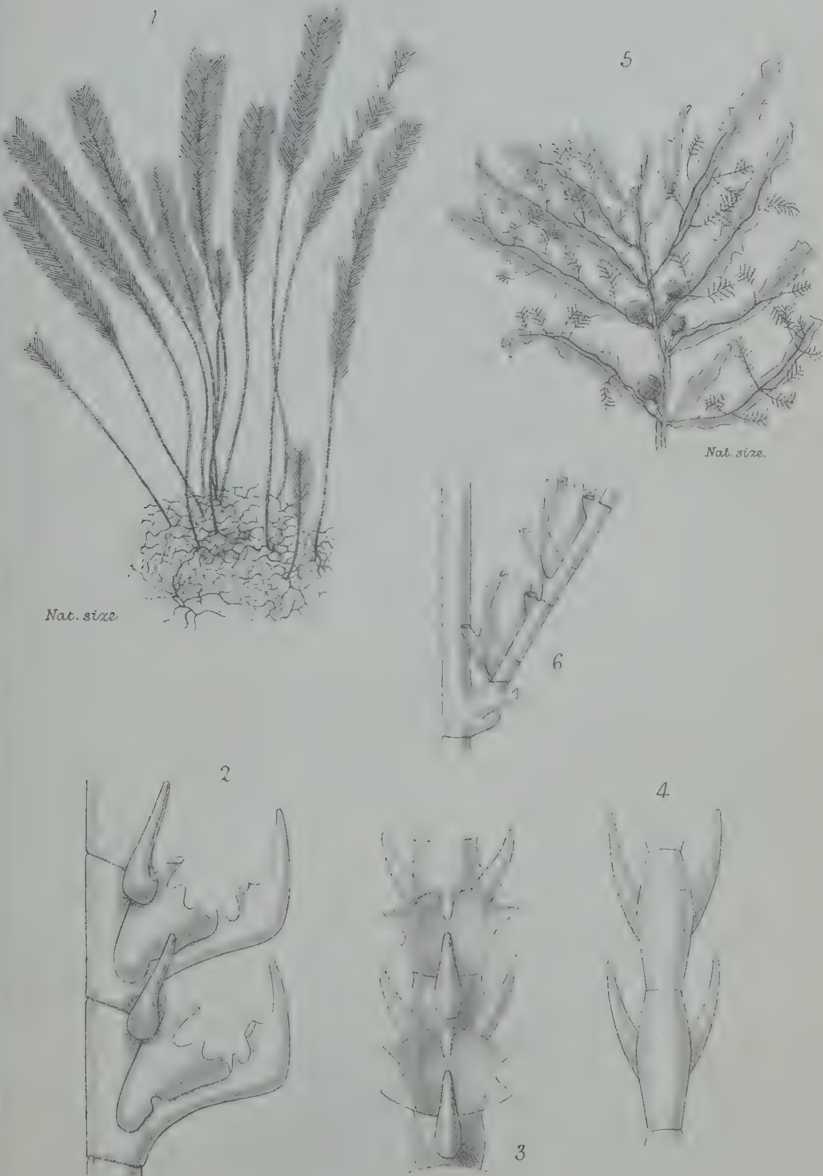
Hollick lith

West Newman, imp.



1–4. AGLAOPHENIA ACUTIDENTATA, Allm.
5–6. HALICORNARIA MITRATA, Allm.

West Newman, imp.



1–4 HALICORNARIA CORNUTA, Allm.

5–6 AGLAOPHENIA LATE-CARINATA, Allm.

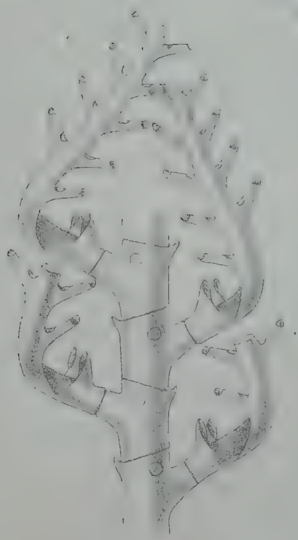
Hollick lith.

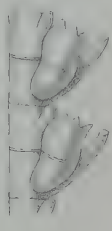
West Newman, imp.

1–4 AGLAOPHENIA DOLICHOCARPA, Allm.
5–7 GATTYA HUMILIS, Allm.

Hollick lith.   West Newman, imp.

Nat size.



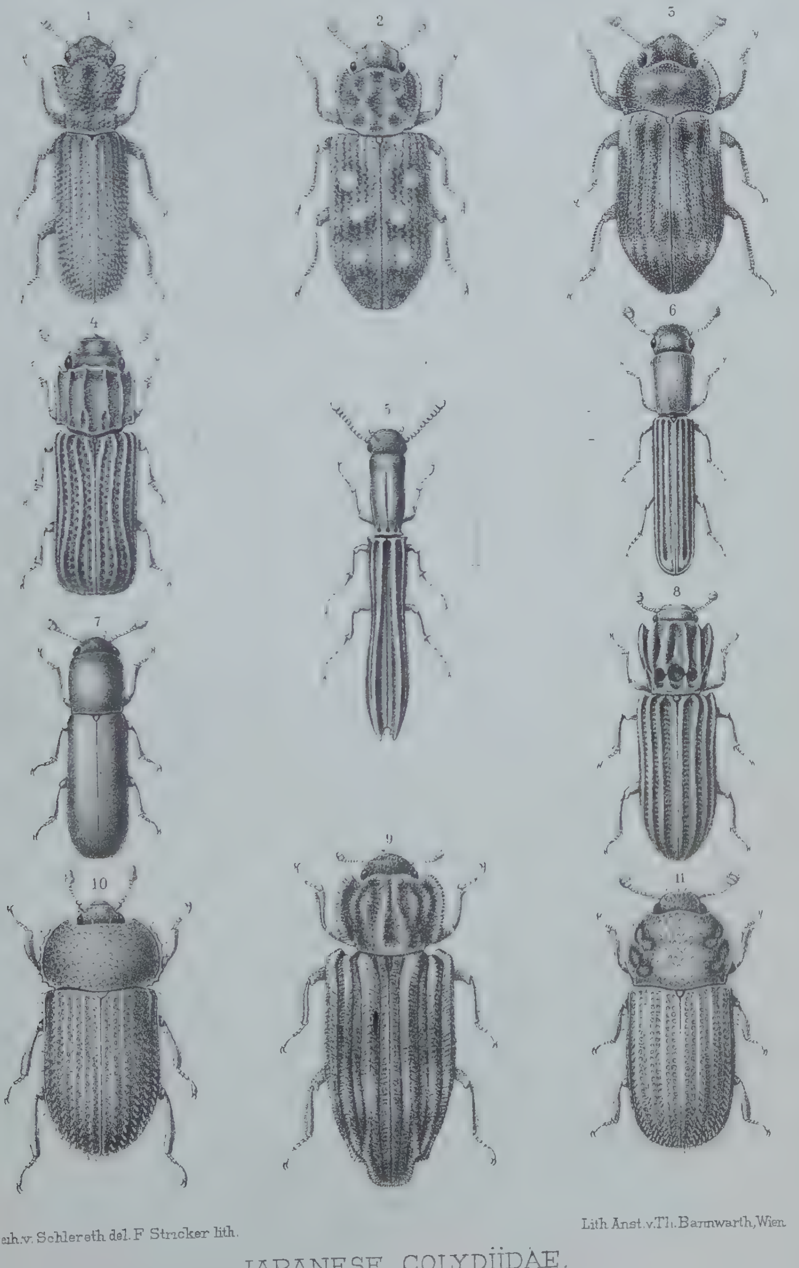


2

Hollick lith. 1–3 LYTOCARPUS RAMOSUS, Allm. West Newman, imp.

West Newman, imp.

1-3 PLUMULARIA LAGENIFERA, Allm. 4-6 P. MULTINODA, Allm.



Freih. v. Schlereth del. F Stricker lith. Lith Anst. v. Th. Bannwarth, Wien.

JAPANESE COLYDIIDAE.

PLATE XXIII.

Figs. 1–4. HALICORNARIA CORNUTA, n. sp.—1. Natural size. 2. Portion of hydrocladium with hydrothecæ, lateral view; magnified. 3. Same, front view. 4. Same, viewed from behind.

5, 6. AGLAOPHENIA LATE-CARINATA, n. sp.—5. Natural size, creeping over a piece of gulf-weed. 6. Portion of main stem with proximal end of a hydrocladium; magnified.

PLATE XXIV.

Figs. 1–4. AGLAOPHENIA DOLICHOCARPA, n. sp.—1. Natural size. 2. Internode of hydrocladium with hydrotheca, lateral view; magnified. 3. Same, front view. 4. Corbula; magnified.

5–7. GATTYA HUMILIS, n. gen. et sp.—5. Natural size, growing over a piece of seaweed. 6. Portion of a colony, showing origin of hydrocladia, from creeping stolon; hydrothecæ seen in profile, with gonangium; magnified. 7. Hydrotheca, front view; magnified.

PLATE XXV.

Figs. 1–3. LYTOCARPUS RAMOSUS, n. sp.—1. Natural size. 2. Portion of a hydrocladium with hydrothecæ; magnified. 3. Portion of a phylactocarp, showing costæ and points from which gonangia arise; magnified.

PLATE XXVI.

Figs. 1–3. PLUMULARIA LAGENIFERA, n. sp.—1. Natural size. 2. Portion of main stem with proximal ends of hydrocladia, and a gonangium; magnified. 3. Portion of a hydrocladium; still further magnified.

4–6. PLUMULARIA MULTINODA, n. sp.—4. Natural size. 5. Portion of main stem with proximal ends of hydrocladia, and a gonangium; magnified. 6. Portion of a hydrocladium; still further magnified.

On the Anatomy of *Sphærotherium*. By GILBERT C. BOURNE, B.A., New College, Oxford. (Communicated by Prof. MOSELEY, F.R.S., F.L.S.)

[Read 19th November, 1885.]

(PLATES XXVII.–XXIX.)

A SHORT time ago Professor Moseley gave me several specimens of *Sphærotherium*, and pointed out to me the existence of a hitherto undescribed stridulating organ in the males of this genus, to which he refers in the article "Myriapoda" in the 'Encyclopædia Britannica.'

The genus *Sphærotherium* was established by Brandt (Bull.

Nat. Moscou, 1833, p. 200), and has been further described by P. Gervais (Ann. de Sc. Nat. sér. 3, t ii.), M. Fabre (Ann. de Sc. Nat. sér. 5, t. vii.), Griffith (Animal Kingdom, i. p. 135), and by C. L. Koch (Myriapoden, 1863). More recently Mr. A. G. Butler has contributed largely to our knowledge of the genus ("A Monographic Revision of the Genera *Sphærotherium* and *Zephronia*," Proc. Zool. Soc. Lond. 1873; Ann. & Mag. Nat. Hist. xiv. 1874, p. 185; Trans. Entom. Soc. 1875, p. 165); and Karsch has drawn up a new classification of the group, founded on the differences occurring in the genital orifices of the females ("Zur Formenlehre der pentazonen Myriapoden," Archiv für Naturgeschichte, 1881).

These authors confine themselves principally to a description of the external features of the animals, and to the establishment of specific distinctions. I have not been able to find a full account of the structure and anatomy of the genus. Unfortunately the specimens in my possession, consisting of several individuals, both male and female, of the species *Sphærotherium obtusum* and *S. retusum*, are so badly preserved, that I am unable to give a complete account of their structure; but I have been able to make out a few points which will, I think, be of interest.

The *Sphærotheria* belong to the order Diplopoda, and the family Glomeridæ. Viewed from above, the general shape of the body, when the animal is extended, is that of an ellipse. The dorsal surface is convex, the ventral surface flattened or rather concave. The head, viewed from the front, is subtriangular in shape, and bears a pair of lateral aggregate eyes, beneath which are the deep fossæ in which the antennæ are lodged. The head is succeeded by a small nuchal plate, and this is succeeded by twelve segments.

The tergites of the body are composed of half-rings of very hard and dense chitin connected together by soft skin: when the animal is extended, these overlap one another to a considerable extent. The last tergite is produced laterally and posteriorly, so as to form a complete shield with an evenly rounded thickened margin covering the posterior end of the body. The lateral margins of all the tergites are produced ventrally, and are inclined slightly backwards.

The first tergite is larger than its successor, and its lateral margins (pleura) are produced into strong, backwardly curved processes, which overlap the two succeeding segments. When the animal is rolled up, the head and posterior end of the body

are brought into close apposition, and the spaces that are left along the inrolled margins of the ventral line are completely covered by these processes of the first tergite, rendering the animal quite safe from attack.

The ventral surface is protected by two rows of chitinous plates on each side. These are figured and shortly described by Brandt (*loc. cit.*). Corresponding to each of the tergites, except the first, is a ventro-lateral plate roughly quadrilateral in form, with the angles rounded off. There are thus eleven of these plates on each side of the body; and they are set nearly at right angles to the pleura of the tergites, which project some way beyond them ventrally. Interiorly to the ventro-lateral plates is a row of twenty-one smaller chitinous plates, on each of which is a tracheal opening. They may be called the *tracheal plates.* Of these, the first three belong to the first three segments of the body. The remaining nine segments have a pair of tracheal plates on each side.

There are twenty-four pairs of appendages in the female and twenty-seven pairs in the male *Sphærotherium.* The antennæ are sunk in deep fossæ on the sides of the head, at once distinguishing this genus from *Glomeris.* They are six-jointed; the terminal joint is truncated and bears a terminal sense-organ, which I shall describe in detail further on. Brandt speaks of seven joints; from his figures it appears that he has counted the plate on which the sense-organ is placed as a seventh joint.

The mandibles are two-jointed, and are typically those of a Diplopod. As in all other Diplopoda, the maxillæ are fused together to form a broad plate behind the mandibles.

There are twenty-one pairs of walking-legs in both the male and female *Sphærotherium.* The first three segments behind the head bear one pair of legs each. The remaining nine segments each bear two pairs of legs. The legs are six-jointed, the terminal joint bearing a small claw. They are well figured by Brandt. The genital openings of both the male and female are on the basal joint of the second pair of legs. An account of these openings and the chitinous valves surrounding them is given by Karsch (*loc. cit.*), who considers them to be of systematic value. No external organs of copulation are connected with the male openings.

In the female the twenty-first pair of legs is succeeded by the anus, which is guarded by a pair of lateral chitinous valves.

In the male three pairs of accessory copulatory appendages are inserted between the twenty-first pair of walking-legs and the anus. Although these appendages have been described by Fabre, and more fully by Karsch, these authors have overlooked several points of importance connected with them.

These three pairs of appendages in the male are clearly accessory appendages developed in connexion with sexual functions, and have no connexion with the segmentation. Whereas each pair of walking-legs has a ganglion developed on the ventral nerve-cord in connexion with it, the copulatory appendages have no ganglia proper to themselves, but are innervated from the twenty-first ganglion (see fig. 14) of the ventral chain; and whilst a pair of tracheal openings corresponds with each pair of walking-legs, there are no tracheæ in connexion with the copulatory appendages.

The first pair of copulatory appendages is small, and each limb is three-jointed. The first joint is small, and flattened from side to side. The second joint is the largest of the three, and posteriorly is produced into a claw-like process. The third joint is hinged upon the base of this process, and closes upon it to form a chela. In this way a simple pair of weak pincers is formed in *S. retusum*; but in *S. obtusum* the chela is modified to form what I believe to be an accessory stridulating organ. A hood-like projection is developed from the third joint (fig. 2, a^1), with its concavity turned towards the claw-like process of the second joint. The interior concave side of this hood-like process bears a number of parallel ridges which work against the claw of the second joint, and in so doing produce a slight grating sound. The articulation between the second and third joints is of such a kind that they do not act together as pincers; but only a lateral motion of the third joint across the claw of the second is possible, whereby the stridulation above referred to is effected.

The second pair of accessory appendages is much stouter than the first; as in them, each limb is three-jointed, and the second and third joints together form a strong pair of pincers, called by Fabre the *forcipules copulatrices*. The shape of these chelæ differs somewhat according to the species; and hence they are of specific value. Fig. 3 is a representation of the chelæ of *S. obtusum*, and figs. 5 and 6 represent those of *S. retusum*.

Although Karsch has described these appendages somewhat minutely, and has given figures of their forms in different spe-

cies, he has unaccountably overlooked the well-defined stridulating-organ developed in connexion with them. This organ is similar in the two species which I have examined, and consists of a prominent bolster-shaped swelling on the postero-external edge of the second joint. This swelling occupies the entire exterior margin of the joint, and shows a number of transverse parallel ridges separated from one another by concave furrows. The whole organ is more darkly pigmented than the adjoining parts, and the crest of each ridge is occupied by a line of nearly black and exceedingly hard chitin. Opposite to this rasp-like organ, on each side, the interior surface of the last tergite is slightly raised into a cushion-like projection, which projection is armed with a number of hard stiff chitinous points. By rapidly rubbing the rasp-like organ on the second pair of accessory appendages against the roughened interior surface of the last tergite, I succeeded in producing a tolerably shrill note, not unlike that of the common house-cricket. There can be no doubt that this is a stridulating apparatus used by the males to attract the females.

The male *Sphærotherium* probably rasps his limb against his tergite a great deal faster than I was able to do, and produces a shrill high-pitched note. As far as I know, nobody has given an account of any stridulation produced by the males of this genus. It would be interesting if any naturalist proceeding to, or living at, the Cape were to observe the habits of the *Sphærotheria*, and give us some account of the stridulation which is doubtless produced by the males.

Observations on the mode of copulation would also be of interest.

The third pair of accessory organs consists of two spike-shaped single-jointed appendages lying between and rather posteriorly to the *forcipules copulatrices.* These I believe to be penes. They are perforated at their extremities, and contain a central cavity; but I was not able to detect any spermatozoa or spermatophores in the latter. When the animal is rolled up they are capable of being applied to the generative openings on the second pair of limbs; but there is no internal communication with the gonads. Until the act of copulation in *Sphærotherium* has been observed, it is not possible to say whether these appendages function as penes or not; but from their position and structure, and from the fact that no other copulatory organs exist in the male *Sphærotheria*, whereas such are present in the allied genus *Glomeris*, I think it highly probable that they do.

The vascular system, alimentary tract, gonads, and genital ducts were so badly preserved in my specimens as not to admit of accurate investigation; but so far as I was able to investigate them, they do not depart in any important particulars from the structure characteristic of the Julidæ. The alimentary tract is bent once upon itself, as in *Glomeris*.

The tracheal system, however, is quite unlike that of the majority of the Diplopoda. In them, as is well known, the stigmata open into as many dilated vesicles, from each of which a tuft of short unbranched tracheal stems, having a very feebly developed spiral filament, are given off. In *Sphærotherium* the tracheal stems are stout, have a well-developed spiral filament, and are much ramified, in this respect resembling those of the Chilopoda and Insecta; but they differ from these in taking their origin, not directly from the stigmata, but from peculiar sac-like cavities, with firm chitinous walls, into which the stigmata open. These internal chitinous structures, which I shall call tracheal sacs, occur in connexion with each pair of walking-legs. A single tracheal sac, with its tracheal plate attached, is represented in fig. 8. It is triangular in outline, somewhat compressed from side to side; and its walls are composed of firm but translucent chitin. At one of its angles it is attached to the tracheal plate, and opens through it to the exterior by an oblique slit-like stigma. From its other two angles stout tracheæ are given off. Each tracheal sac lies with its longest axis at right angles to the long axis of the body of the animal. The tracheæ springing from its innermost angle, near to the median line, are distributed to the viscera; those springing from its outermost or distal angle supply the powerful lateral and dorsal muscles of the body. Three stout tracheæ, springing from the first pair of tracheal sacs, are distributed to each side of the head.

The tracheal sacs and their stigmata have precisely the same relation to the segmentation of the body as have the walking-legs. Thus each of the first three body-segments has one pair of tracheal sacs, the remaining nine segments two pairs each, making twenty-one pairs in all. A diagram of the tracheal sacs and their relations is given in fig. 8.

Glomeris, which is in all its characters closely allied to *Sphærotherium*, is also distinguished by the presence of branched tracheæ (Gegenbaur's Comp. Anat., English edit. p. 288); and the same is doubtless the case in the allied genus *Zephronia*.

But beyond the bare mention of the fact in the work above quoted, I have not found a description of their tracheæ in any other author; and the differences in the tracheæ are generally considered to rank among the leading distinctions between the Diplopoda and Chilopoda.

It seems that the tracheæ of *Sphærotherium* are a transition from those of the *Julus* type to those of the *Scolopendra* type. I do not, however, infer that any genetic relationship exists between *Sphærotherium* and the Chilopoda. The whole anatomy of the former points to its being a highly specialized Diplopod, in which, in accordance with its high specialization, the tracheal system has become more fully developed than in the other members of the group to which it belongs; and the development has been in the same direction as in the Chilopoda and Insecta. The resemblance in fact is due to homoplasy, not to homology.

The tracheæ of *Sphærotherium* may be derived from those of *Julus* and *Peripatus*; and the tracheal sacs are, no doubt, homologous with the tracheal sacs in both these forms. The presence of the tracheal sac is a primitive character which is found only in the Prototracheata and Diplopoda. In *Sphærotherium* the primitive character of the sacs is altered in so far that the tracheal stems are no longer given off as a tuft from the surface of the tracheal sac, but two primary stems are given off, one from the dorsal part of the sac lying nearest to the median line, the other from the extreme lateral prolongation of the sac, with which the tracheal stem appears to be continuous. The primary stems soon branch; both they and their branches have well-developed spiral filaments, and their ultimate ramifications extend through all the tissues of the body.

It may be observed that in *Sphærotherium* the openings of the tracheal sacs on the surface of the body are clearly the *stigmata*, and not the openings of the tracheæ into the tracheal sacs. This is worth mentioning, because a writer on *Peripatus* has denied that the sac-mouths are the true stigmata, and has confined that name to the openings of the unbranched tracheæ into the sacs (Gaffron, "Beiträge zur Anat. und Histologie von *Peripatus*," Zool. Beiträge von A. Schneider). He regards the latter simply as invaginations of the skin; but the tracheæ themselves are nothing more than invaginations of the skin modified for respiratory purposes; and it is better to regard the tracheal sacs as an integral part of the tracheal system, and the sac-mouths as the true stigmata.

As is shown in my diagram (fig. 14), there is a complete correspondence between the walking-legs, the stigmata, and the ganglia of the ventral nerve-cord; and these structures occur twice in every segment after the third. I have not yet seen a satisfactory explanation of this double segmentation in the hinder region of the bodies of the Diplopoda; nor am I able to offer one myself, though I have given much thought to the subject. Until we arrive at a satisfactory solution of the origin of metameric segmentation itself, it will scarcely be possible to explain this additional complication which has been grafted on it.

The nervous system is quite similar to that of *Glomeris*, which is described by Leydig (Tafeln zur vergleichenden Anatomie: erstes Heft, Taf. vii. figs. 3 & 5). As stated above, there is a small ganglion on the ventral nerve-cord corresponding with each pair of legs. From each ganglion a pair of nerves is given off to the legs, and a pair of nerves runs outwards dorsally to the tracheal sacs. The accessory appendages of the male derive their nerve-supply from the last ganglion of the ventral chain.

The eyes are aggregate, each being formed of a group of closely apposed simple eyes. Those of my specimens were unfit for microscopical examination.

The antennary sense-organ is especially well developed in *Sphærotherium*. Leydig was the first to call attention to the existence of terminal sense-organs on the antennæ of *Julus*; and in his figures of the nervous system of *Glomeris* (*loc. cit.*) he draws the nerve-endings on the antennæ of that genus.

Although these antennary sense-organs are conspicuous, their histological structure was not described until Bütschli gave a short account of them in the 'Biologisches Centralblatt,' No. IV. 1884, p. 113. He gives a woodcut of the structure of the sense-organ of *Glomeris*; but his account and his figure are mostly from memory, and he does not pretend to very great exactness.

In *Sphærotherium* the terminal joint of the antenna is truncated, and the truncated surface is covered with a thin flat plate of chitin. On the surface of this plate stand up a number of conical or spike-like chitinous projections, each being surrounded by a white ring with a dark pigmented border. In the antenna which I have figured (figs. 9 & 10) there are eighteen such projections; but the number is not constant, varying from fifteen to twenty. Their number is much less in the Julidæ: in a

large *Spirobolus* from Ceylon I found four; and in different species of *Julus* only two or three. These projections are little conical caps of chitin perforated at their extremities, and containing the terminal nerve-fibres of the organ of sense. It was very difficult to obtain good sections of this organ. The only method was to imbed the antenna in paraffin and then to cut close round it and pick away the chitin bit by bit, afterwards re-embedding the soft parts, and cutting a series of sections in the ordinary way. The antennæ of my specimens being small as compared with the bulk of the body, were better preserved and fit for histological purposes.

The antennary nerve breaks up in the penultimate joint into as many branches as there are nerve-endings on the terminal joint, and each branch is continued into a spindle-shaped bundle of nervous tissue which lies in the terminal joint. Thus there are a number of these bundles lying side by side in the terminal joint of the antenna, and each mass lies directly underneath, and is continued into one of the conical projections described above.

Each bundle of nerve-fibres, as it passes into a spindle-shaped body, breaks up into a number of branching and anastomosing nerve-fibrils, forming a *neurospongium*. From the neurospongium proceeds a bundle of nerve-fibres, which are beset in their course with a number of ganglion-cells. These cells are nucleated, and lie along the nerve-fibres so as to give the appearance of regularly arranged parallel linear series of cells (see figs. 11 and 12). The nervous bundles are thickest in the region of these nerve-cells; beyond them the bundle tapers away somewhat rapidly, and consists of closely-packed fine nerve-fibres which run up towards the conical projections on the end of the antenna, and enter into close connexion with the bases of the fine sense-hairs, which protrude slightly through these projections. The bundles are isolated from one another by connective tissue, and fine tracheal branches run between them right up to the end of the antenna.

Lying among the branched connective tissue-cells and surrounding the proximal ends of the nervous bundles are a number of large oval cells, each with a distinct oval nucleus, which stains deeply with hæmatoxylin or borax-carmine. Whatever the nature of these cells may be, they are certainly not ganglion-cells, and give off no processes continuous with the nerve-fibres (fig. 12, *c*).

Bütschli describes a proximal set of large nucleated *ganglion-cells*, and a distal series of smaller *sense-cells* as occurring in each bundle. It is evident from his figures that the cells which he calls true sense-cells correspond with those which I have described as ganglion-cells; whilst he has taken the large oval nucleated cells referred to above to be ganglion-cells occurring in the proximal end of the sense-organ. But the cells in question lie outside the nervous bundles, among the connective tissue which surrounds them; they have not the structure of ganglion-cells, and are found in all parts of the antenna, and are by no means confined to a zone surrounding the proximal ends of the nervous masses in the terminal joint. In the proximal part of the antenna these cells are confined to definite spaces in the connective tissue, and I believe that they are nothing more than blood-corpuscles, which would be amœboid in the living state, but have assumed an irregularly oval shape under the action of spirit. Definite lacunar channels appear to lead through the antenna, and to open into relatively large lacunar spaces which surround the proximal ends of the nervous masses in the last joint. Hence in spirit specimens one finds a mass of blood-corpuscles aggregated round the nerve-masses, and more particularly around that part which I have described as being a neurospongium. In thick longitudinal sections these cells appear to form part of the nerve-substance; but in thin sections and in transverse section (fig. 13) they are easily seen to be quite distinct from it.

No doubt, as Bütschli says, the antennary organs of the Diplopoda are comparable with those of *Peripatus* on the one hand (see F. M. Balfour, "Anat. and Devel. of *Peripatus capensis*," Quarterly Journ. Micr. Science, 1883, p. 213), and with those of *Vespa Crabro* and other insects on the other (see Häuser, "Geruchsorgan in Insecten," Zeits. f. Wiss. Zool. xxxiv. p. 367). Häuser adduces physiological proof of the olfactory function of these organs in insects; but without definite proof I should hesitate to attribute the same function to the organs of Diplopods, and prefer to call them simply "antennary organs."

It is commonly stated that there are no auditory organs in Myriapoda, but the existence of a stridulating organ in the male *Sphærotherium* postulates the existence of an auditory organ, in the female at any rate. Leydig, in his 'Tafeln zur vergleichenden Anatomie' (erstes Heft, Taf. vii. figs. 3 and 5), figures what he calls an "eigenthümliches Sinnesorgan" occurring on the

head of *Glomeris marginata*. This is a horseshoe-shaped organ lying beneath the eye on either side of the head, and supplied by a special nerve coming from the hinder part of the cerebral ganglion. In the description of the plates he gives the following account of it:—" . . . besteht aus einer hufeisenförmig Vertiefung der Haut, von beiden Seiten durch vorspringende Ränder bis auf eine schmale Spalte geschlossen. . . . Von Boden erhebt sich ebenfalls ein hufeisenförmig gebogener Wulst. Derselbe dient zur Aufnahme einer gangliösen Nervenendigung."

Lying within the antennary fossa, just beneath the eye, in *Sphærotherium*, is a small round opening, surrounded by a thickened rim of darkly pigmented chitin. This opening leads into a small cavity, which seems to be lined with sensory epithelium, and to be a sense-organ corresponding to the horseshoe-shaped organ described by Leydig in *Glomeris*. This organ is supplied, as in *Glomeris*, by a nerve springing from the hinder part of the cerebral ganglion. The organ is enclosed between two plates of exceedingly dense chitin, meeting at an acute angle to form a ledge projecting over the antennary fossa, and all my attempts to cut sections of it, or to make a preparation fit for microscopical examination, failed. I tried several times, but unsuccessfully, to dissect out the organ from the chitin that surrounds it.

I must therefore confine myself to pointing out the position of the organ, and its homology with Leydig's organ in *Glomeris*. My conviction is that these are true auditory organs.

Unfortunately, as I am soon leaving England, I have not had time to obtain living specimens of *Glomeris* and investigate Leydig's organ with a view to determining its function. It will not be out of place here to call attention to the fact that one of the Chilopoda is known to stridulate *. The fact that this chilopod does stridulate points to the existence of an auditory organ in at

* Gerstäcker (Stettin. Entom. Zeit. 1854, p. 312, Taf. ii. fig. 1) describes in *Eucorybas crotalus*, a chilopod, a sound-producing apparatus: the hindermost pair of legs have their fourth joints much enlarged and leaf-like, with their edges raised and formed of hard chitin. When moving, and especially when excited, these two laminar appendages are rubbed against one another and thereby produce a rasping sound. It is curious to observe further that the third joint on the inner side is produced into a process, and forms, with the fourth joint, a weak pincer-like apparatus, though Gerstäcker does not state that it has any such use. *Eucorybas* is also a South-African myriapod, being found at Port Natal.

least one member of the group, and I have no doubt that a closer investigation will show that it is of general occurrence.

The character of the trachea, the curved alimentary tract, the numerous chitinous pieces composing each segment, and the presence of a special sense-organ on the head, mark off the family Glomeridæ, to which *Sphærotherium* belongs, very sharply from the other families of the Diplopoda.

In conclusion I must express my thanks to Professor Moseley, who kindly gave me the specimens with which I have worked, and assisted me in many other ways.

I am also much indebted to my friend Mr. W. Baldwin Spencer, who has kindly undertaken to see my work through the press during my absence from England.

EXPLANATION OF THE PLATES.

Plate XXVII.

Fig. 1. Lateral view of a large specimen of *Sphærotherium obtusum*, nat. size.

2. *S. obtusum.* Left first accessory appendage of the male, viewed from behind. 1, proximal joint; 2, middle joint; 3, distal joint. *p.* Claw-like process of middle joint at the base of which the distal joint is articulated, thus forming a chela. *a.* Hood-like process on distal joint. a^1. Parallel ridges on *a* which work againt the process *p*, thus forming a stridulating organ.

3. Second pair of accessory appendages of *S. obtusum*, ♂. 1, 2, 3. The three joints of the appendage. *f.* The *forcipules copulatrices* (Fabre) formed by the middle and distal joints. *a.* Stridulating organ. *b.* Penes.

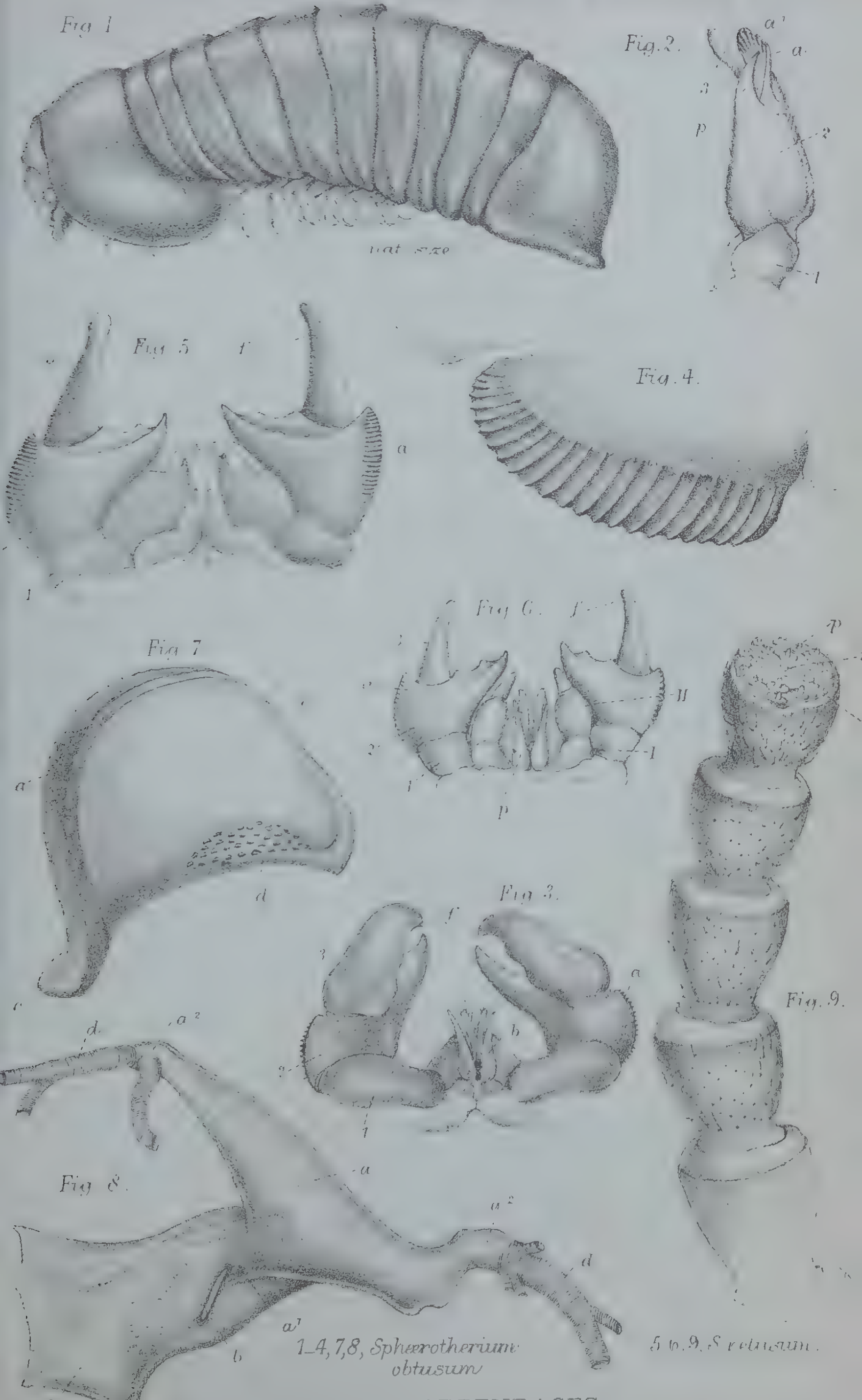
4. Stridulating organ on the second accessory appendage of *Sphærotherium*, much magnified.

5. Accessory appendages of *S. retusum*, ♂, viewed from behind. 1, 2, 3. Joints of second accessory appendage. *f. Forcipules copulatrices.* *a.* Stridulating organ.

6. The same viewed from in front. I. & II. The first and second accessory appendages. 1, 2, 3. Joints of second appendage. *f. Forcipules copulatrices.* *a.* Stridulating organ. *p.* Penes.

7. The last shield-shaped tergite of *S. obtusum.* *a.* External surface. *b.* Concave internal surface. *c.* Thickened and produced inferior margin. *d.* The rasp-like stridulating cushion developed on the internal surface and against which the stridulating organ (fig. 4, and *a*, figs. 3, 5, 6) works.

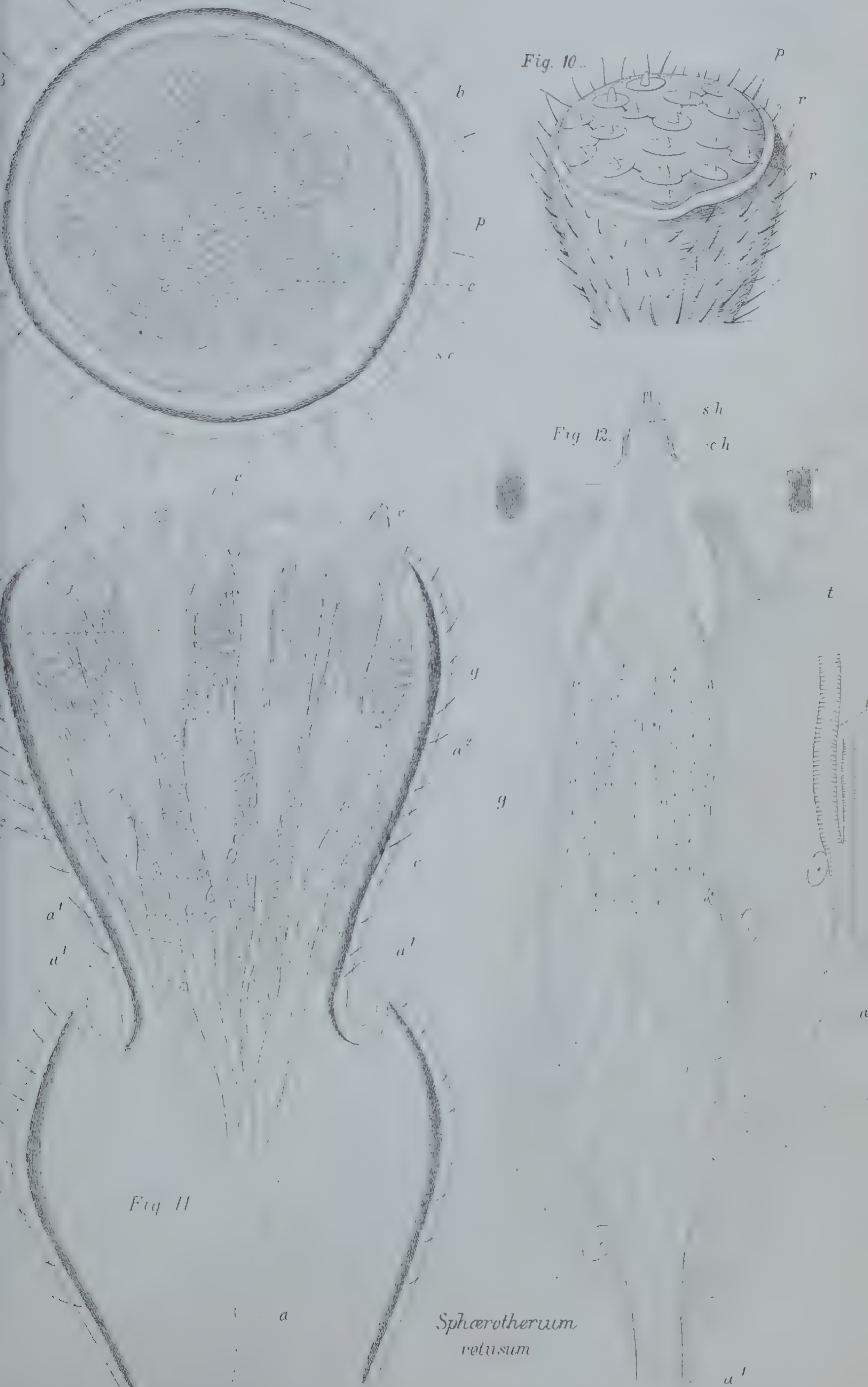
8. Single tracheal sac of *S. obtusum*, viewed from the inner side, and attached to its tracheal plate. *a.* Tracheal sac. a^1. Angle of the sac which is attached to the tracheal plate (*c*). a^2, a^2. The two angles of the sac from which spring the tracheal tubes (*d*, *d*). *b.* Stigma, opening into the tracheal sac at the angle a^1.



1-4,7,8, *Sphærotherium obtusum* 5, 6, 9, *S. retusum*.

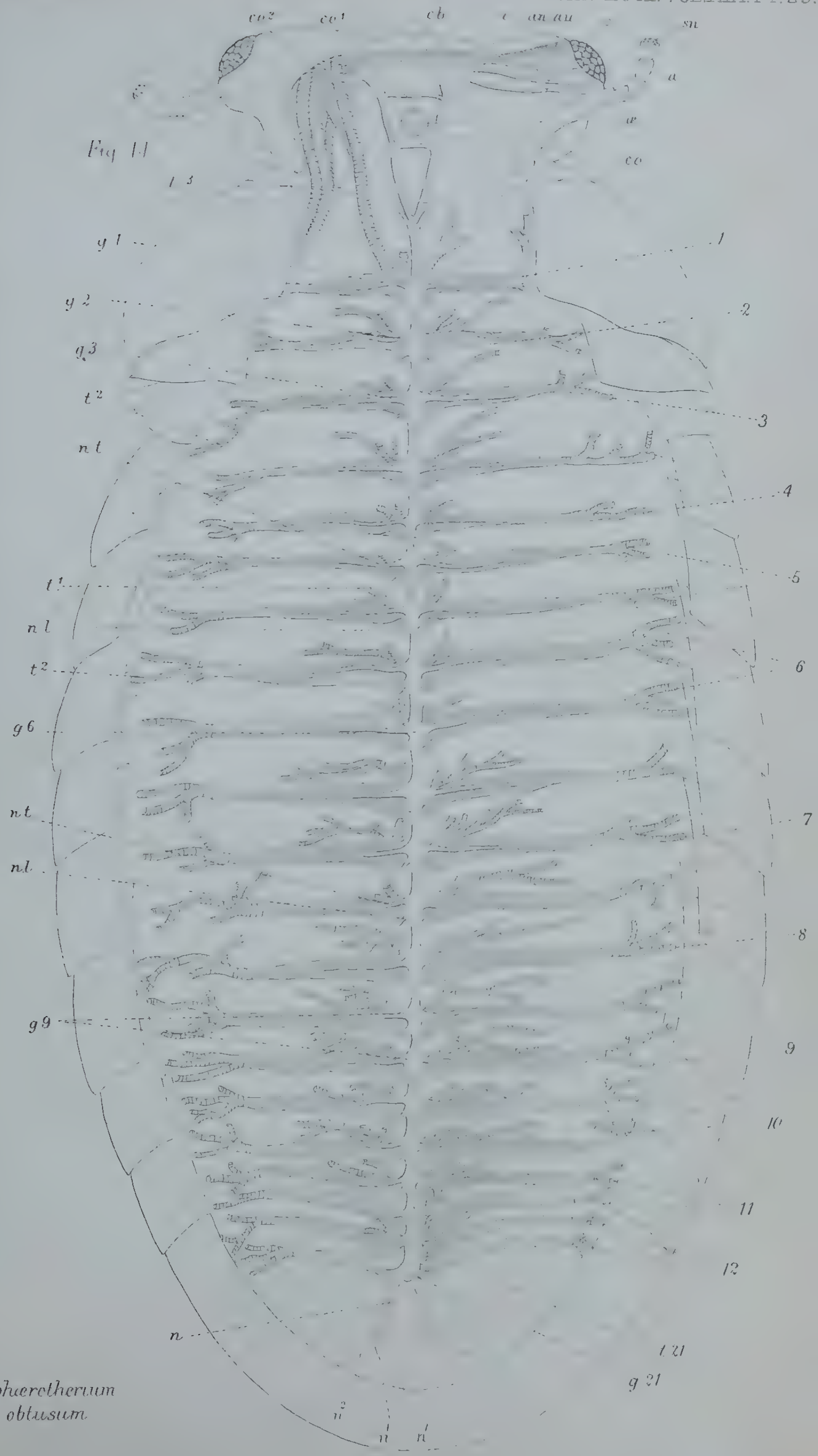
ACCESSORY APPENDAGES

Berjeau lith. Mintern imp.



ANTENNARY SENSE-ORGAN & SECTIONS.

Mintern imp.



Sphaerotherium obtusum

Fig. 9. Antenna of *S. retusum*, showing the terminal sense-organ. *p*. The processes in which are the sensory hairs. *r*, *r*. The white ring surrounding each process.

Plate XXVIII.

Fig. 10. A still further enlarged view of the end of the antenna of *S. retusum*, showing the sense-organ: the lettering as in fig. 9, Pl. XXVII.

11. Diagrammatic longitudinal section of the antennary organ in *S. retusum*. *a*. Antennary nerve. a^1, a^1, a^1. The branches of the nerve, one going to each nerve ending in the terminal point. a^2, a^2. Nerve-bundles formed of neurospongium. *c*. Large ovoid cells (blood-corpuscles?) lying in the connective tissue (*t*) which surrounds the nerve-bundles. *g*. Ganglion-cells. *e*. Terminal sense-organs.

12. A single nerve-bundle, much magnified. a^1. Branch of antennary nerve. a^2. Neurospongium. *g*. Ganglion-cells. *s.h*. Sensory hairs surrounded by a chitinous cap (*c.h.*). *t*. Connective tissue. *tr*. Tracheæ. *c*. Large ovoid cells (blood-corpuscles?).

13. Diagrammatic transverse section through the antennary organ, much magnified. *b*. Nerve bundles in section. *c*. Large ovoid cells (blood-corpuscles?). *s.c*. Subcuticular layer of cells. *p*. Pigment.

Plate XXIX.

Fig. 14. Diagram of the tracheal and nervous system of *S. obtusum*. *a*. Antenna. *an*. Antennary nerve. *au*. Auditory (?) nerve. *cb*. Cerebral ganglion. *co*. Nerve-commissure. co^1 and co^2. Nerves joining the two strands of the commissure above and below the œsophagus. *e*. Eye. *g* 1, *g* 2, *g* 3. The ganglia of the three first body-segments. *g* 6, *g* 9. The pairs of ganglia belonging respectively to the sixth and ninth body-segments. *g* 21. The last ganglion, being the hinder one of the pair belonging to the twelfth segment. *n*. Nerve arising from the last ganglion, and supplying the accessory appendages of the male. n^1, n^1. Larger nerves to the appendages. n^2. Smaller nerve to the penes. *n.l*. Nerve supplying the leg; one pair arises from each ganglion. *n.t*. Nerve to the tracheal sac, one pair arising from each ganglion. *o*. Optic nerve. *œ*. Œsophagus cut through. *sn*. The sense-organ on the terminal antennary joint. t^1. Tracheæ, arising from the tracheal sac near the middle line, and supplying the viscera. t^2. Tracheæ arising from the tracheal sac near the lateral line on either side and supplying the dorsal and lateral muscles. t^3. Three large tracheæ arising from the first tracheal sac and supplying the head. *t* 21. The last tracheal sac, being the hinder one of the pair belonging to the twelfth body-segment. 1, 2, 3. The single tracheal sacs in the first three body-segments. 4, 5, 6, 7, 8, 9, 10, 11, 12. The pairs of tracheal sacs belonging to the nine posterior body-segments.

Notes on Parasites collected by the late Charles Darwin, Esq.

By T. Spencer Cobbold, M.D., F.R.S., F.L.S., Hon. Vice-President of the Birmingham Natural History and Microscopical Society.

[Read 3rd December, 1885.]

In the autumn of 1869 I received a letter from Mr. Darwin as follows:—

Down, Beckenham, Kent,
August 9.

"Dear Sir,—

"In looking over some bottles with specimens in spirit from S. America and adjoining seas, collected by me nearly forty years ago, I find a few parasitic worms, which it has occurred to me you might possibly like to have. Should this prove the case, be so kind as to inform me and they shall be sent to you. I have looked at only one lot, viz. from the *Rhea*, or American Ostrich, and these seemed not in a bad state; 2nd, worms from stomach of a Porcupine; 3rd, from the mouth of a Snake; 4th, from the wild *Cavia Cobaya*—these might be compared with any worms from the domestic Guinea-pig, which some authors think (I believe falsely) to be descended from the *C. Cobaya*. Also three sets from fish; but as I was very ignorant when I collected them, these perhaps are Lerneæ or their allies. Should you care to have these specimens, I will give exact locality and date at which they were preserved.

"Pray believe me,
"Dear Sir,
"Yours faithfully,
"Charles Darwin."

Having promptly accepted the offer I soon received the specimens, with a list of dates, and also of numbers corresponding with others stamped on metallic labels in the bottles referred to. In reference to the parasites from a *Capybara* Mr. Darwin, at the same time, corrects a passage in the above-quoted letter, remarking thus:—"N.B. I see I made a mistake and spoke in my letter of *Cavia Cobaya*."

Although the collection is a very small one, and although shortly after receiving it I gave some account of two of the parasites in papers contributed to the Zoological Society, I have thought that a more complete notice of the collection ought to be

placed on record. The data, though fragmentary, will at least serve to show that Mr. Darwin paid more attention to parasites than many of the later travelling naturalists who have enjoyed far larger opportunities of collecting them.

1. FILARIA HORRIDA, *Diesing*.

F. rheæ, *Owen*.

Dicheilonema, *Diesing*.

Up to the year 1874 I had seen no figure of this entozoon; but the species was at that time readily identified from the descriptions of Owen and Diesing. Mr. Darwin's specimens comprised three male and seven female worms, and were distinctly labelled, "From the stomach of a Rhea, Bahia Blanca, North Patagonia, 1832." At the time of writing the paper quoted below, I thought it not improbable that Mr. Darwin had anticipated Natterer's discovery. Such was not the case. The original finds of this entozoon were made by Natterer at Arica, Cuyaba, and Caiçara in 1823–4–6 respectively; all the worms being lodged within the cavity of the thorax of the host. Full particulars of the finds and an excellent account of the anatomy of the worms are given by Diesing. It is noteworthy that the longest of Darwin's female specimens was under 30 inches, whilst Natterer's largest worm was over 33 inches, and Schneider gives the greatest length attained in a specimen as beyond 52 inches, or up to 1360 millim. I may mention that when engaged in forming a special collection of Entozoa for the Hunterian Museum in 1865, I found several unnamed specimens of this worm in the store-rooms of the College. They had doubtless been given to Prof. Owen by Natterer some 25 years previously, for I find that Diesing makes mention of such a donation. In his well-known article "Entozoa," quoted below, Owen speaks of a female worm as being "about 30 inches in length." My measurement of one of the same series gave a length of 35 inches. Schneider's subsequent account of the number and position of the oval and caudal papillæ cleared up all doubts which existed on these anatomical points. Considering the affinities of this entozoon with the Guinea-worm, it would be a great gain to possess some knowledge of its development. Not improbably entomostracous crustaceans play the rôle of intermediary host.

The literature of *Filaria horrida* now stands as follows:—

OWEN.—Art. Entozoa in Todd's Cyclopædia of Anat. 1839, p. 141; Lect. on Comp. Anat. 1843, p. 74; and 2nd ed. p. 109.

DIESING.—Syst. Helm. vol. ii. 1851, p. 278. Denkschr. d. kais. Akad. Wien, xiii. 1857, S. 19 (plates). Revis. d. Nemat. 1860, S. 709.

MOLIN.—Monogr. d. Filarien, in Sitzungsber. d. k. Akad. Wien, xxviii. 1858, S. 416.

COBBOLD.—Catalogue of Entozoa in Museum Roy. Coll. Surg. 1866, p. 8. Proceed. Zool. Soc. of Lond., Nov. 1873, p. 737 (figs.).

SCHNEIDER.—Monogr. d. Nemat. 1866, S. 89.

O. VON LINSTOW.—Compend. d. Helminth. 1878, S. 126.

2. OXYURIS OBESA, *Diesing*.

In Mr. Darwin's list this species is marked "Worm from duodenum of *Cavia Capybara*, floating amidst the green digesting mass: Rio Plata, May 1833." The bottle contained five females. The original find of this species was made by Natterer at Ypanema, in 1819, when he obtained large quantities from the cæcum of a *Capybara*. They were all females; at least, Diesing's description implies so. When in 1876 I gave some notice of Mr. Darwin's find, I was not aware that Schneider had already described this species. Diesing had said that the head was armed with three or four prominent papillæ, but Schneider observed and figured six, the same number of papillæ having been seen by myself. At present, no one appears to have seen the male *Oxyuris obesa*, which is not surprising considering the rarity of the males of several allied species. Schneider remarks upon the variable size of the female, his smallest specimen measuring only 7 millim. and the longest 30 millim.; nevertheless all the worms were mature. I may state that the variable length of the female *Oxyuris curvula* of the horse is even more striking; for, whilst Schneider fixes the extreme length at less than 2 inches (45 millim.), I, on the other hand, have frequently obtained specimens between 3 and 4 inches, and in one example nearly 5 inches in length (118 millim.).

The literature of *O. obesa* is meagre.

DIESING.—Syst. Helm. 1851, vol. ii. p. 141. Denkschr. d. kais. Akad. Wien, xiii. 1857, S. 12. Revis. (*op. cit.*) S. 141.

SCHNEIDER.—Monogr. d. Nem. 1866, S. 121 (figs.).

COBBOLD.—Proceed. Zool. Soc. March 1876, p. 297 (figs.).

O. V. LINSTOW.—Compend. 1878, S. 26.

3. ASCARIS SIMPLEX, *Rud.*

A. delphini, *Rud.*

In Mr. Darwin's list some parasites referable to this species are marked "Worms from stomach of a Porpoise off the I. of

Chiloe, Jan. 1835." The set comprises thirteen specimens, mostly females, the longest of which does not exceed 3 inches. It was Rudolphi who first suggested that the *Ascaris* found by Lebeck in a Gangetic Dolphin belonged to the same species. This view was confirmed by myself from an examination of Nematodes procured from a *Platanista gangetica* by Dr. John Anderson. I think it highly probable that the *Ascaris* found by Krefft and Masters in a Dolphin captured in Port Jackson is of the same species. If so, the worm occurs in *Delphinus phocæna*, in *D. Forsteri*, in *Platanista gangetica*, and probably in Dolphins generally. Be that as it may, the whole question of Cetacean Nematodes requires careful revision. I will only at present remark that the ova from Mr. Darwin's specimens are nearly spherical, furnished with thin, transparent chorional envelopes. They give an average diameter of $\frac{1}{650}$ of an inch from pole to pole. M. Dujardin, whose description of the species is the best on record, found the eggs to be a trifle larger.

The literature of this parasite is poor and much scattered.

Lebeck.—In Neue Schrift. d. Berl. Gesell. Naturf. Fr., Bd. iii. S. 282 (*non vidi*).

Rudolphi.—Entoz. Hist. Nat. vol. i. p. 170. Synops. Ent. 1819, pp. 49, 54, 296.

Dujardin.—Hist. Nat. d. Helm. 1845, p. 220.

Diesing.—Syst. Helm. vol. ii. 1851, p. 155.

Van Beneden.—Bull. de l'Acad. roy. de Belg. 1870, p. 119.

Krefft.—Trans. Entomol. Soc. N.S.W. for July 3, 1871, p. 8.

Cobbold.—Proceed. Zool. Soc. 1876, p. 279. Linn. Soc. Journ., Zool. 1876, vol. xiii. p. 43. 'Parasites,' Lond. 1879, p. 426. 'List of Parasites,' Int. Fish. Exh. 1883, nos. 71, 73.

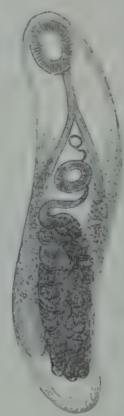
O. v. Linstow.—Compend. 1878, S. 59.

4. Distoma incerta, n. sp.

Body smooth, with very fine tubercles in front; oral sucker oval, subterminal, nearly twice as large as the acetabulum; intestine simple, with wide cæcal ends; folds of uterus numerous, reaching to within a short distance of the tail; eggs oval, minute. Length $\frac{1}{16}''$ to $\frac{1}{8}''$.

This small Trematode is catalogued by Mr. Darwin as a "Worm from mouth of a Snake allied to *Coluber*; Maldonado, Rio Plata, May 1833." I am reluctant to proclaim the species as new to science, but after careful comparison with the *Distoma Boscii* found by me in the mouth, trachea, and lungs of an American Coluber that died at the Zoological Gardens in 1858, I am

satisfied that the two forms are not identical (Trans. Linn. Soc. vol. xxii. p. 364, pl. 63. figs. 6, 7). In like manner I have compared it with Diesing's *Distoma clava* (found by Natterer in *Coluber flaviventris* as well as in several allied S. American snakes, including *Cloelia fasciata*, in which latter host the worms were on one occasion taken from the throat). Certainly, Mr. Darwin's fluke corresponds with *D. clava* more nearly than it does with *D. Boscii*, but there are differences apart from the remarkable disparity of size. In the new species the vitellaria are confined within the central part of the body and the reproductive papilla occupies the usual position, well above the acetabulum. The eggs are very numerous, of a dark-brown colour, having a long diameter of about $\frac{1}{1000}''$, whereas the ova of *D. Boscii* measure fully $\frac{1}{750}''$ from pole to pole.



Distoma incerta.
× 35 diam.

The remaining parasites are Ectozoa.

5. Lernea branchialis.

This species is marked: "Worm buried in the tail of a *Gadus*; T. del Fuego, Mar. 1833." Of the three specimens of female epizoa, two were perfect. Excepting the length of the neck, they differ in no essential from the ordinary species attached to the gills of the Cod. In the example dissected, the neck was imbedded beneath the skin to the extent of $\frac{3}{4}$ of an inch, the so-called head being branched in the usual manner. These epizoa were included in the English collection of parasites at the International Fisheries Exhibition, 1883.

6. This refers to a solitary specimen marked: "Worm from under branchial covering of fish; T. del Fuego, 1834." It is evidently a lernean allied to the ordinary *L. branchialis*, but displays a large number of loose filaments attached to and nearly concealing the body. The head is wanting. Int. Fish. Exhib., "List of Parasites," no. 23.

7. Specimen marked: "Worm on scale of fish; T. del Fuego, Jan. 1833." Repeated examination of the scales and underlying muscular fibres yielded no trace of any parasite.

8. "Worm from branchiæ of *Lota* or *Gadus*; when caught protruded a transparent case full of eggs; T. del Fuego, Jan. 1834." This lernean is also lost.

On the Perignathic Girdle of the Echinoidea. By Prof. P. Martin Duncan, M.B. Lond., F.R.S., F.L.S., &c.

[Read 19th November, 1885.]

(Plates XXX. & XXXI.)

Contents.

I. Introduction and Terminology.

The first definite notice of the nature and use of the perignathic girdle with which I am acquainted, was written by that careful anatomist the late Dr. Sharpey, F.R.S., in the 'Cyclopædia of Anatomy and Physiology.' In the article "Echinodermata" (1839, vol. ii. pp. 33 & 36) he gives views of the parts; but although he describes the muscles of the jaws and their attachments and origins, and explains the nature of the "auricles" to a certain extent, he disposes very briefly of the ridges or plates which are between the auricles in the Echinus he anatomized. He may be quoted as follows:—"At its lower edge the shell sends inwards a process in form of an arch over each pair of the ambulacral columns." The figure (10 *a*, p. 33) shows the arches and also the intermediate structure. On page 36 it is stated:—"The muscles and ligaments belonging to the dental apparatus partly pass between its different pieces and partly connect it with the border of the shell. It will be recollected that the border of the shell forms five processes which rise in the form of arches into its cavity round the lower aperture."—"Two muscles come from every arch."—"Other ten muscles arise in pairs from the border of the shell in the interval between the arches."

It is evident that Sharpey gave the information which was current at that time and that the "auricles" were well known,

but that the interauricular parts were confounded with the border of the shell. The connection of the auricles of *Echinus* with the ambulacra was both drawn and described.

J. Müller (Bau d. Echinodermen, Berlin Akad. 1854) gives a most perfect figure of a *Cidaris* and describes the "auricles" from that genus only. He figures the ambulacrum with the projecting knobs seen within the test on either side of the median line, and terms them vertebral processes. Nothing can be clearer than the fact so well illustrated by the great anatomist, that these "auricles" have no connection with the ambulacra and that the ascending processes in *Cidaris* are interradial.

It is evident that the "auricles" of *Echinus* noticed by Sharpey are not homologous with the auricles of *Cidaris* as described by Müller.

Lovén, in his wonderful 'Études,' p. 29, in treating of *Cidaris*, states:—"Là les auricules n'offrent pas de résistance. Fixées par leurs bases exclusivement aux plaques interradiaires des deux côtés de l'ambulacre," &c.

Lovén gave moreover the following very important description of the "auricles" of other genera:—"L'existence d'un appareil masticatoire puissant et très-compliqué, pourvu de cinq pièces d'appui, dites auricules, dont les bases élargies sont fixées par soudure à la face interne des plaques péristomiennes et subpéristomiennes du test, *soit ambulacrales, soit interradiales*, &c." The meaning of this refers to the difference in the position of processes in *Cidaris* and the true auricles of all the other Gnathostomes (Clypeastroids excluded) with which Lovén was cognizant.

A. Agassiz, in the 'Revision of the Echini,' 1872–74, p. 689, states:—"In the Desmosticha, on the other hand, the jaws are placed entirely within the line of the auricles, from which they are supported by a very complicated set of muscular bands, extending in pairs from the sides of the auricles, from their base and from the intervening spaces, to different points of the pyramid and of the braces."

On the next page he writes:—"The auricles are interambulacral processes: they are developed from the test itself, and do not belong to the dental system as stated by Lovén, while the teeth and jaws are developed independently as isolated pieces in young Echini.

"In the Cidaridæ the processes of the adjoining interambu-

lacral auricles are closely connected, and appear to be more intimately connected than in Glyphostomata, where the interambulacral processes on each side of the intervening ambulacral space form an arch which may or may not be closed, and of which the extremity is more or less closely soldered together."

A. Agassiz gives excellent figures of the auricles and pays much attention to their condition in the Clypeastroids.

It is perfectly clear that there is a great diversity of opinion between Lovén and Agassiz.

T. H. Stewart gave a description of the jaws and of their muscles and their attachments to the body of the test. The description was accompanied by a drawing, and, as might be expected, they are models of clearness and correctness.

The form which Stewart investigated (Proc. Zool. Soc. 1861, p. 53) was not one of the Cidaridæ, and the origin of muscles from "auricles" and intermediate interradial ridges clearly proves that the arrangement is not the same in the Cidaridæ (see J. Müller's figure) and in the other regular Echinoidea with jaws.

Charles Stewart examined the structures of *Dorocidaris papillata* and gave an excellent description of the internal branchiæ, of the jaw-chamber, and of the compasses and their use. In illustrating his paper ("On certain Organs of the Cidaridæ," Trans. Linn. Soc. vol. i., Second Series, Zool. pt. xxii. p. 569, pl. lxx., 1877) the author gave an excellent figure of the top of the jaws, the compasses and their ligaments, the branchiæ, and the part of the test between the ambulacra to which some muscles are attached.

There are also two admirable drawings of the ambulacra, and Müller's vertebral processes are well shown; and their spinulose analogues, which Mr. Stewart noticed curving over the ambulacral vessels, are represented *.

Terminology.—The term "Auricle," taken from fancied resemblance to little ears of the arched processes of the structures which give attachment to the jaw-muscles, is one which should lapse.

* Wyville Thomson held that the structures I call the "perignathic girdle" were distinct from the test. In his essay in the Phil. Trans. vol. 164. pt. ii. p. 731, he states that in the Echinothuridæ "the ring of calcareous elements forming the auriculæ and their uniting ridges appears to be entirely distinct, merely forming adhesions with the ambulacral and interradial elements."

The shape of the so-called auricles of the Cidaridæ differs from that of the other Echinoidea, and the construction of the part in Discoidea differs also. No ear is like unto any one of these structures, and they have nothing whatever to do with hearing.

Very frequently the arch of the processes is incomplete, and then there is no possible similarity between them and the outlines of an ear.

It is proposed to discontinue the term auricle. No definite name has been given to the ridge-like plate which connects the so-called auricles together, and which really is of as much importance as the processes, which arch more or less over the ambulacra.

The whole of the structures of the test which give attachment to the muscles of the jaws require a name, and that of the *perignathic girdle* seems to have some useful qualities.

The girdle is, when fully developed, continuous, and consists of arched processes and intermediate ridges. The discontinuity may be slight or very decided.

The Cidaridæ differ entirely in the arrangement of their jaw-muscles, so far as attachment to the test itself is concerned, from the other dentate regular Echinoidea, and the solid so-called "auricles" are parts of the interradia. There are no ambulacral processes for the retractor muscles, and therefore the girdle is discontinuous.

In Discoidea there is a continuous girdle without arches, although the homologues of the processes exist *.

The terms *ambulacral process* and that of *ambulacral arch* should replace the terms "auricle" and "auricular arch." In speaking of the jaws and their accessories for muscular attachment, the word *process* or *arch* will suffice; and the term *interradial ridge* may be employed, with or without the word interradial, to distinguish the ridge-like structure which unites the ambulacral arches and gives attachment to the protractores and radiales.

II. The Perignathic Girdle of the Cidaridæ.

A small but well-developed specimen of *Dorocidaris papillata*, Leske, presented the aspect of the discontinuous perignathic

* The anatomy of the test of *Discoidea cylindrica* will form the subject of a future communication to this Society.

girdle which was so well drawn by J. Müller, and figured, with the aid of photography, by A. Agassiz in the 'Revision.'

The processes do not exist, and the tall, stout, notched, and sideway-slanting interradial ridges form the whole of the discontinuous girdle. An interradial ridge is high and broad, and notched on its upper edge at the median line, so as to give the appearance of being formed by two halves placed side by side, and a vertical suture passes down from the notch to the peristomial margin *.

The upper edge of each half of the ridge is convex and thin, and is produced sideways so as to partly overhang an ambulacrum, (Plate XXX. figs. 1 & 2). The outer, that is the circumferential, surface of the ridge is slightly convex from side to side and from above downwards: and internally the surface is slightly concave above and rather tumid below. The upper edge overhangs the concave surface at the upper part of the ridge on either side of the median line, and this surface is the point of attachment of muscles. In the midst of this concave surface, and about halfway down the ridge, there is a small depression on either side of the median line and midway between the outer side of the ridge and the median line. The sides of the ridge are curved, concavity towards the ambulacra, and the suture between the ambulacral plates and the ridge on either side is nearly vertical at the peristomial edge (fig. 1).

The general direction of the ridges is upwards and slightly outwards, so that they are not vertical, and the lower part of each ridge projects more towards the axis of the animal than the upper and free part (fig. 3). The lower part has tubercles in relation to it actinally, and the characteristic ununited plates of the Family are attached to the lower and inner part of the ridge where it merges into the peristome, and the union is membranous. Circumferentially the ridge slopes rather sharply at first from above downwards, and then more gradually so as to merge into the upper surface of the coronal plates near the peristome. The ridge is thin above, and stout lower down where it joins the general surface of the plates just mentioned (figs. 2 & 3).

Seen from without, the outer (circumferential) surface of the ridge has the median suture of the interradium coming in a

* Benzene was used when requisite to render the sutures distinct.

zigzag close to its starting line from the ordinary level, and it is very perceptible (with benzene, and sometimes without that excellent distinguisher of sutures) that the median suture passes up the median line of the ridge, but not in a right line, there being a slight curving (fig. 2).

The sides of the ridge on either side of its median suture correspond with zones "*a*" and "*b*" of the interradium, and it appears at first sight as if the side of the ridge corresponding with zone "*b*," for instance, was composed of a long plate the circumferential angle of which extended beyond the ridge and assisted to form part of the interradium, and that in the ridge the zone "*a*" was composed of the whole of a plate *.

But it is evident that in zone "*b*" the apparently long plate is not a whole one, for there is a delicate suture which passes from the convexity of the curve of the median suture, as seen from within the test, and has an oblique upwards and sideways course. This suture unites a small terminal plate (figs. 2 & 4). There is no such plate in the other zone (*a*).

Both of these zones are limited by an ambulacro-interradial suture.

The direction of the sutural union of the terminal plate of zone "*b*" with the plate immediately external or circumferential to it is from the outer surface of the ridge inwards and downwards and it terminates actinally. Hence this small plate comes to the under or actinal surface of the test, and it carries there the smallest of the interradial tubercles at the peristome. The plate external to the small one has its sutural union also oblique and reaching the actinal surface, and it is recognized there as the second plate of the zone "*b*" which carries the first large tubercle (fig. 3). On the other hand, the plate of zone "*a*" which forms the whole of one side of the ridge reaches actinally and carries there the first largest tubercle of the interradium. The ridges of the girdle in *Cidaris* are thus composed of an upward growth and thickening of the first and second interradial plates in one zone, and of the first plate in the other zone, and there is no additional structure. There are no structures in *Cidaris* which resemble or are homologous to the processes of the girdle of the other families of the regular Echinoidea. J. Müller and C. Stewart have described and drawn certain nodular projections, which are almost spines in places, on the ambulacral plates; their position is on either side

* Interradium 5 (the odd posterior) is chosen for illustration.

of the median suture of the ambulacrum, and the vertebral processes as they were termed by Müller, as well as the spines, are elevations of the interporiferous parts of the plates. Some of the projections unite on the side of the median line and others nearly arch over the vessels and nerves in that situation. No muscular fibres are attached to the projecting nodules.

The peristomial edge of the first ambulacral plates of *Cidaris* is low, and a pair of pores will be seen, if care is taken, on either side of the median sutural line (fig. 1).

These pairs are continuous with those of the first pairs seen on the actinal surface of the solid test; and it is evident, from their position on the ambulacral edge within the peristomial membrane, that no muscular attachments can come in on that inner edge.

In the Cidaridæ all the muscles which protrude and retract the jaws arise from or are attached to the interradial ridges.

In *Cidaris*, owing to the particular character of the peristomial membrane which is covered with separate plates, the jaws cannot appear so clearly outside the test and beyond the membrane as in *Echinus* for instance. The retractores of *Cidaris*, which open the jaws inferiorly, are not so much required as they are in *Echinus*, which extends and widely separates and gapes the ends of its jaws in an astonishing manner. Hence the processes of the girdle are all important in *Echinus* and can be done without in *Cidaris*, the ridges being sufficient.

Goniocidaris geranioides, Lmk.—The perignathic girdle resembles that of *Cidaris* (*Dorocidaris*): the ridges are well developed; the "vertebral processes" of the interporiferous zones of the ambulacra are small.

The ambulacra are narrow at the peristome, and no part of them contributes to the girdle. The first two ambulacral plates are rather high, in comparison with those of *Dorocidaris*, at the peristomial edge, and the upper surface is often notched at the median line. A pair of pores is seen on the inner surface of each of the first ambulacral plates, and these openings are close to the upper edge of the plates; they correspond with the first pairs of pores visible on the actinal surface of the test. The peristomial membrane and its plates are attached to this inner surface of the ambulacral plates, below the position of the pores, and consequently there are no muscular origins or attachments on the plates.

A line of suture separates the interradia from the ambulacra

at the peristome, and it can be traced readily on the free inner surface of the test at the peristome (fig. 8).

Each interradium has a tall, forked ridge occupying the whole width of the area; there is a vertical median line denoting that the ridge is composed of at least two plates, one from each zone, and the flanks of the ridge are produced sideways above, so as to overhang the ambulacra more or less. The direction of the ridges is strictly obliquely upwards and outwards, and they are rather tumid low down and more or less concave near their upper edge.

It is evident that a ridge is composed of an upward growth of the first coronal plates (one plate in zone *a* and two in zone *b*), and its base corresponds with the first pair of interradial tubercles of one zone, and of the largest tubercle near the peristome of the other zone. There are no perforations on the flanks of the interradial ridges of the girdle, and, as will be seen further on, the ridges, like those of *Dorocidaris*, are not homologous to the processes of other Echinoidea.

The comparatively high inner edge of the first ambulacral plates is very suggestive in relation to the corresponding part in Discoidea; but it does not appear that the height is due in *Goniocidaris* to anything else than the usual elevation which separates the ambulacral plates one from the other, in vertical succession. The plates are tall and have a transverse elevation on their upper surface.

Phyllacanthus imperialis, Lmk.—There are two good specimens of this form in the British Museum, and one shows a most interesting difference from the usual type of the perignathic girdle in the Cidaridæ. In one specimen the free edge of the ridges is very deeply notched and the ridge is low at the median line and high at the sides, which overhang the ambulacra considerably and with a double curve. In the other the median notch is deep, and the sides of some ridges are so produced over the ambulacra that they either absolutely unite with the opposite ridges or very nearly do so. (Figs. 5 & 6.)

In one instance the union over an ambulacrum is so perfect that the idea of a perignathic process cannot but arise in the thoughts of the observer. There would be room in this arch for the usual muscular attachments of a process (fig. 7), as in the Echinidæ.

III. The Temnopleuridæ.

It was thought best to take a species of the Temnopleuridæ as an example of the characteristic perignathic girdle of the Glyphostomata of the Regular Echinoidea, on account of the readiness with which the sutures of the plates separate.

Salmacis bicolor, Agass.—The large specimen of this species which was examined in the first instance has a large and fully developed perignathic girdle, which is continuous, and consists of five ridges and five arches, each of these last being made up of two processes united above (fig. 9). The whole girdle is stout, tall, and slopes obliquely upwards and outwards.

The ridges of the girdle are rather tall, and have a sharp upper free edge, with a projection at the spot above the median line, and there is a slight concave or downward bend of the edge on either side of the median process. The upper edge bends inwards very slightly, and immediately below it, on the inner or peristomial surface of the ridge, is a slight hollowing on both sides of an imaginary median line, for the attachment of a muscle; and below these hollows is a decided transverse concavity, which is placed immediately above the inward projection of the base of the ridge, which corresponds to the bases of the first two tubercles seen on the actinal surface. This transverse hollowing is not very broad, for there is a more or less vertical groove on either side of the same surface of the ridge, which is pronounced below on either side of the basal projection, and which becomes shallow towards the top of the ridge, where it is lost. These lateral grooves (β) are continuous with the "cuts" for the branchiæ, and they nearly entirely belong to the ridge; but a small part, and that forming the side of a groove towards the ambulacra, is on a girdle-process. The line of suture which passes obliquely from above downwards (s), and which indicates the union of the ridge and a perignathic process, marks the outer part of the branchial groove. This suture commences above at the free edge of the ridge, where the upward slope of a neighbouring process begins, and it has a direction obliquely downwards and sideways, so that the base of a ridge is broader than its free upper edge (fig. 9).

The ridges are thin from without inwards at their tops, and they become thicker towards the base, and this corresponds at

the actinal surface of the test with the first tubercles of the interradial area (fig. 10).

Although the sutures of this species are so readily separable, and the plates can be isolated so easily, still no separation will take place down the median line of a ridge (figs. 11 & 12). On the other hand, it is noticed that one of the zones (*b*) of the interradium has a large plate coming to the base of the ridge, and separated from the plate which forms the bulk of it by a transverse line of suture, whilst the other zone (*a*) has a small plate which forms only a small part of the ridge in advance of the plate of zone *b*. The succession of large interradial plates, and the presence of a very low plate in one zone, and of the great plate of the ridge, which has no median or other suture, are very constant peculiarities in this and other specimens (fig. 11). The direction of the inner or peristomial sutures of the plates at the base of the ridge is from above, inwards and downwards obliquely; and the relation of the large plates to their tubercles on the actinal surface of the test can be easily seen, but that is not the case with the small plate, for usually it is too high up (fig. 12), nevertheless it may have a vestige of a primitive tubercle. The great plate (zone *a*) which forms all the rest of the ridge is evidently placed over the first large tubercle of its zone of the interradium. Both plates in zone *b* have tubercles actinally.

In a smaller specimen of the same species the ridges were easily separated from the adjacent processes at the lines of suture, and the separated faces of the ridge showed lines of sockets and intermediate lines of depression and furrowing * (fig. 12). These corresponded with knobs and ridges on the separated face of the process; and when both surfaces were studied, it became evident that a third and upper plate entered into the composition of the ridge (figs. 12 & 13).

Were it not for the presence of the relics of a suture on the sides of the ridge there would be no reason why the undivided plate of a ridge should not be named plate 1, and be made common to both zones, as in so many edentulous Echinoidea. Then the plates in zone *a* would be Nos. 2 & 3, &c., and in zone *b*, 2 & 3 (fig. 11). But this cannot be correct. Plates 2 cannot be thus numbered, for there are *at least* three plates. (See further on.)

The examination of the ridges proves that they are composed

* See Duncan, Journ. Linn. Soc., Zool. vol. xvi. p. 353.

of interradial plates, and that there has been union of the terminal, or rather primary, plates so as to obliterate the median and other sutures. The ridges are united by separable sutures with the processes, are grooved for the branchiæ, and are marked by muscular impressions. Two sets of muscles are attached on each side of the inner face of a ridge—the thread-like radiales, probably ligamentous, and the large and broad protractores.

Variation.—The size of the median projection on the upper free edge varies, and is often absent in young specimens.

The processes of the girdle enclose an ovoid and rather pointed opening over the peristomial part of each ambulacrum, and the tall, broad processes, upwardly curved at the top, contrast with the comparatively small openings. The processes of each ambulacrum are joined by a vertical suture in the median line above, are broad from side to side and thin from before backwards, and slightly bent inwards superiorly, although the general direction of the processes is that of the whole girdle, namely upwards and slightly towards the circumference of the test. The slope of the side margins of the processes to reach the tops of the ridges is abrupt, and the suture which unites them with the ridges is long vertically and rather narrow from within outwards. When this suture is separated, the articulating surface of the process being exposed, it is found to present opposite characters to those of the corresponding part of the ridge. There are numerous knobs (fig. 13) placed in a space close to the base, and above they are limited by a set of lines of knobs and elevations more or less oblique in direction. Above are some more knobs and linear ridges, and quite at the top of the surface there are other knobs. The impression given is the same as that noticed in describing the corresponding surface of the ridge, except that in the process the markings are all convexities, and in the ridge they are all receptive concavities. It is evident that the relics of the borders of three plates exist.

At the peristome the edge of an ambulacrum, which is bounded by the origin of the process on either side, is low and is marked by the ambulacral median suture, and by grooves and pores on either side of it, for the passage of structures which come from the inside of the test to reach the bases of the actinal pedicels (figs. 9, 11, 14). The pores on either side of the median line are placed on the ascending base of a process and on the peristomial face. On looking at the process at its back and ambulacral side, at least

two pairs of pores and as many incomplete plates can be seen to form the foundation and much of the ascending part of each process (figs. 11 & 14).

These plates have distinct sutural lines (under benzene) between them and at the median line; but their outer or ambulacro-interradial sutures are not seen, and the plates therefore merge into the general mass of the process on their side remote from the median line (fig. 14). The direction of the plates is very oblique.

Next to these plates, towards the radial end of the ambulacrum, are broader ones (Nos. 5 and 6, fig. 14), which have their interradial sutures visible and in contact with the more or less vertical suture of the ridge and process, as it merges into the common ambulacro-interradial suture. These do not add to the bulk of the process.

The union of the plates at the base of the processes is too decided to admit of separation, and it appears, therefore, that the processes are the result of the combined growth of the whole of the poriferous parts and some portions of the interporiferous zones of the first four or five ambulacral plates.

The possibility of the upper part of the processes being a structure superadded to the ambulacral plates arises from the fact that fracture occurs very readily between the middle of the process and the top, and along an oblique line from one side downwards and inwards towards the median line of the ambulacrum. No other line of ready fracture occurs, and the surface of the fracture is plain and smooth. Nevertheless the use of benzene does not distinguish any line of suture or of union at the part.

Temnopleurus toreumaticus, Agass.—Small specimens were examined in the first instance, and their perignathic girdle appears to be smaller comparatively than that of *Salmacis*, the processes are not so broad, are more delicate, and the small opening is oval and not sharply angular in outline superiorly, as is the case in *Salmacis*.

The ridges are not high in relation to the height of the processes, and they are broad. The upper edge of a ridge is thin and bent, with a bold downward curve, and there is no projection. The grooves in continuation with the cuts for the branchiæ are not very pronounced, but the projection inwards of the usual peristomial swelling immediately over the tubercles is decided.

Hence there is a hollow above this swelling, and between it and the upper edge. There are markings for the insertion of protractor muscles on either side of the median line. The sutures between the sides of a ridge and the corresponding processes are slightly oblique and nearly vertical; they commence on the upward slope of the ridge, and the direction of the sutural line is sideways and away from the median line of the ridge and downwards. The result is to make the breadth of the base of the ridge broader than the upper edge.

There is no median suture to be traced in the ridge by means of benzene, and when the structure is examined from within the test (circumferentially) it appears that the arrangement of the coronal plates in the zones of an interradium near to and in the ridge is very simple. In one zone a coronal plate with distinct sutures forms part of the ordinary plane surface of the test close to the rising up of the ridge, and the rest of the plate contributes to a small portion of the ridge. It is therefore a plate with a curved upper surface, and it is thick from within the test actinally, and carries a tubercle on the actinal surface. In the other zone a coronal plate comes to the edge of the rising part of the ridge, and enters very slightly indeed into the ridge itself. It is followed by a low but broad plate, which forms a part of the ridge, and reaches to about the same height in it as the single coronal plate of the opposite zone.

The whole of the ridge above these plates is composed of a single plate without the trace of a suture in it, median or otherwise, and it is sutured to the plates just noticed inferiorly, and with a process on either side. The arrangement is as in *Salmacis*.

The processes unite above in a broad arch, and they are thin there and have a line of vertical suture. They are stout at their bases, and there is a decided projection passing down the internal surface (that looking towards the jaws), which slopes obliquely towards the ambulacral median line separating the first pair of pores from the second. The side of the base of a process towards the ambulacral median line has four sets of pores on it. The first pair has its pores close and oblique; and a little care shows that the pair do not belong to one plate, but that the pore nearest the peristomial edge is in relation with a groove in the edge, and that they are the apertures of the first plate. The other pore of the pair is in relation with the groove on the edge nearer the median line than the other, and the groove and pore

are the apertures of the second plate. (See the fig. 14 of *Salmacis.*) The pair of pores next to this last on the flank of the process are close, and the outer or aboral pore is a long way off the suture between the ridge and the process. The pair belongs to a third plate, and its sutures are visible, under the effects of benzene, between it and the plates, nearer and further from the peristome; but no suture can be traced towards the division between the process and the ridge, and therefore the part of the plate remote from the ambulacral median line merges into the mass of the process, as in *Salmacis.* The next pair of pores are on the flank of the process which trends circumferentially, and the pores are more distant than the others; they belong to a plate which is not separable from the process. The succeeding pair of pores are wide apart, and they belong to a compound plate, which has all the sutural lines visible under benzene, and therefore this plate does not form a part of the foundation of the process. Four plates at least enter into the composition of the base and upward-stretching parts of the process.

The suture between the ridge and a process, when seen from within the test, passes almost in a right line to reach the flat upper surface of the actinal part of the test, just beyond the slope of the ridge, and then it clearly becomes continuous with the ambulacro-interradial suture.

It must be understood that the position of the pairs of pores on the flank of a process is very oblique, and that the direction of what remains of their plates is upwards and sideways from the direction of the median suture of the ambulacrum. This uptilting enables the plates to add to the height and thickness of a process.

Microcyphus zigzag, Agass.—This species has a thick test, and the peristomial edge bends in, and although it is said not to have "cuts," they are as evident as are the small and narrow grooves continuous with them on the inner side of the perignathic ridge.

The perignathic girdle is high, and the processes are rather slender; they are united by suture superiorly, and the space they enclose is somewhat triangular. The base of a process and the part formed by the first four or five ambulacral plates resembles that of the Temnopleuridæ already noticed.

The ridges are tall and comparatively narrow, and the free upper edge of each is curved downwards, or there may be a projection on the edge at the median line (fig. 15). The

suture between one side of a ridge and a process is tall, nearly vertical, slants but slightly, and it traverses the outer edge of the branchial groove. The peristomial swelling over the actinal tubercles is usually tall, and not united in one mass, but more or less separated along the median line as well as transversely. Immediately under the somewhat overhanging upper edge of a ridge are two distinct depressions, one on either side of the median line, and the base of each depression is curved downwards, and there is a blunt projection between them at the median line. The height of the ridges is remarkable.

The direction of the girdle is as in the other forms, and is upwards and slightly outwards, that is towards the circumference.

Amblypneustes ovum, Agass.—The perignathic girdle is stout, high, and oblique.

The ridges are broadest below, and the whole of the groove on either side of one comes within its area, so that the suture between the ridge and the process is oblique from the upward slope of the ridge downwards and towards the median line of the ambulacrum.

The free edge of the ridges is curved, and there is a median projection.

The processes slant gradually from the upper edge of the ridge and are rather narrow, they join above by median suture; and each is expanded laterally there. The space included is tall, triangular, and rounded slightly at the angles.

It is quite evident that the Temnopleuridæ have the perignathic girdle made after a different plan to the Cidaridæ, and it is proved that the processes which enclose the opening over the peristomial part of the ambulacra are parts of the ambulacra. The processes are made up at their bases and to a certain height by combined and deformed and, to a certain extent, displaced ambulacral plates, and especially of their poriferous areas. A process is united to the ridge on the interradial area by suture. A ridge consists of interradial plates and there is a single plate which forms the greater part of the ridge at and below its free upper edge. There is no separation of the interradial ridge of the perignathic girdle into two parts by a median suture as in *Cidaris*.

There are some points about the origin and structure of the perignathic girdle which are not quite clearly made out in the Temnopleuridæ, and it is therefore necessary to consider the girdle in the Echinidæ, and in some of the other Triplechinidæ and Polypores also.

IV. The Echinidæ.

Echinus norvegicus, Düb. et Kor.—The perignathic girdle is very delicate and incomplete in the young forms, but becomes strong and well developed in adults. The processes of adults are high, and rather broad from side to side above the margin of the upper edge of the ridges. They are united as a rule along the median line above, and the included space is of moderate size; it is broad below and more or less angular above, and the sides of the space are curved inferiorly and slant to the upper angle. The base of a process slants in the direction of the median line of an ambulacrum; and it is limited, on the interradial side, by a line of suture, which slopes from the curved edge, where the ridge merges above into the process, to the actinal surface of the test, just on the ambulacral side of the slight cut and groove for the branchiæ. The direction is in a curve downwards and towards the median line of the ambulacrum. The result is to increase the width of the part of the peristome which is in relation with the ridge, and to diminish the width of the base of a process. The upper part of a process has a well-marked upper edge with depressions below it for muscular attachments, and the area of these is also increased by the expansion of the process on either side above. The ascending part (fig. 17) is obscurely triangular in transverse outline when fractured across, and there is a projecting line which passes along the peristomial side, that is the true inner face of the process, so as to cross the base obliquely. This line separates the pores and grooves of the first ambulacral plates, which are at the very edge of the peristome, from the three plates which are seen at the back part of the base of a process (fig. 17). Taking the basal part of the first process that comes to hand, it will be noticed that the peristomial edge is marked by three grooves (fig. 16)—the one nearest the median line of the ambulacrum being small and without a corresponding pore, whilst the others have each a pore corresponding with them, that of the groove furthest from the median line being high up on the base, the other pore being lower down.

On the back part of a process three minute pores may be seen, forming a curve, the third pore being further from the ambulacral median line than the others. These pores, which are oval with a minute angularity below, are the outer pores of so many plates, the inner pores of which are larger and much nearer the

ambulacral median line. The sutures between the plates to which the pairs belong are seen with benzene, but their ambulacro-interradial sutures do not exist; for the plates, the direction of which is very oblique from above and towards the median line of the ambulacrum, merge into the mass of the process at their part remote from the median line. Thus in this species, as in the Temnopleurids, the base of the process is certainly composed of parts of the poriferous zone of ambulacral plates increased in height and crowded.

It is necessary to admit that the ambulacral plates which are visible at the peristomial part of the process—that is, the first, second, and third plates, and those three others seen on the process behind it, that is plates 4, 5, 6 of the ambulacrum—may enter into the composition of the base, and of more or less of the upper part of the process in one zone *a*, in a specimen of nearly adult dimensions. In the opposite process (fig. 17) two plates are in front and three behind the process, and none have ambulacro-interradial sutures; they compose the process of zone *b*.

The perignathic ridges of this species are low, and they are curved downwards at the upper free and narrow edges. The width of a ridge at its edge from suture to suture is less than the width of the peristomial part of the corresponding interradium. On the peristomial face of a ridge there is a swelling at and on either side of the median line and just above the actinal edge. On either side of this there is a groove which is continuous with a branchial cut, and above the swollen part there is a concavity surmounted by long markings for the attachment of the protractor muscles (fig. 16).

On examining the other side of a ridge, or from the circumference inwards, it is to be noticed that there is no median suture near the edge, and that under benzene certain plates become very distinct. A single plate, which is relatively much less developed in height than in the Temnopleuridæ, forms the whole edge of a ridge, and it varies in height according to age. Following this plate, in one zone (*a*), there is a low plate and a higher one, and all the low plate and a small part of the next enter into the formation of the ridge's base. On the other zone a large plate succeeds the single one, and part of it rises in the base. (Figs. 24 and 18: the transverse line *a*′ is the level of the rise of the base. Provisionally the plates of fig. 24 are numbered as if they were in direct and normal succession; the single plate is 1, and it is followed by 2,

3, and 4 in the zones. But the correct numbering must follow on the examination of some of the other groups, for, as suggested in *Salmacis*, the single plate was really not such a structure originally.)

A large form, closely allied to the species just considered, has tall and broad processes, which are expanded laterally on each side of the vertical median suture above. The opening they enclose is a tall triangle in shape with the angles rounded. The ridge is very low, much curved downwards at the free edge, and marked on each side of the bulge of the base of the tubercle-bearing plates at the peristome by the groove leading to the branchial cuts. The bulge is not simple however, and it is made up of two sides with a median depression. The sutures between the processes and the ridges are very distinct.

Young Form.—The growth of the perignathic processes was attempted to be understood by the examination of a number of small specimens of *E. norvegicus*, varying from 5 to 8 mm. in diameter. In the smallest form the plates of the test were few, and those of the ambulacra were distinct and wide apart. The processes were the merest nodules, were widely separated, short, and with a narrow and almost circular base (fig. 21); they were united by suture to the ridges, and the line of union was distinct even without benzene, so that it was perfectly evident that the stunted growths were not on interradia but on ambulacra (fig. 23). Every process was a portion of the first ambulacral plate, on either side of the median line at the peristome, and it was evident that the position was on the outer poriferous portion of the plate for the first pair. The first pair of pores were pushed towards the median line by the base of the process, and the aboral pore of the pair perforated the base of the process (fig. 17).

The position of the base of the process was then on the poriferous zone close to the edge of the peristome, and close to the ambulacro-interradial suture. It is proved, therefore, that the process is not homologous with the so-called "vertebral processes" of Müller, which are growths of interporiferous areas, and there can no longer be a doubt that the processes are ambulacral growths and not interradial. Even at this early age the processes had feeble muscular slips. The ridges were very low and insignificant, and their edge was composed of an entire plate as in adults, and it was a miniature of the ridge already described and drawn in fig. 24. Slightly larger specimens showed the processes to be taller

and still disunited (fig. 20); and the suture between the processes and the ridges could be separated, and then it was seen that there were at least two plates forming a ridge (fig. 22): nothing could be seen with any reagents which would prove that the single plate was divided in the youngest and smallest forms. The largest of the specimens showed that the processes unite above very soon, and that they grow upwards with the general growth of the test (fig. 19).

Echinus esculentus, Linn.—There is an excellent preparation of a large test of this species in the British Museum, and the girdle is well shown. The processes are large, broad, and rounded above, and the position of their vertical suture, which was high, cannot be seen even with benzene, for perfect union has occurred. The space included by the arch of the processes is large and the ridges are well developed, and they have the usual number of plates.

Psammechinus miliaris.—If the characters of the structures of the perignathic girdle of *Echinus* be remembered, it will only be necessary to treat of those of the corresponding parts of this species briefly. The processes of the girdle are rather tall, and are rather narrow superiorly, where there is normally a slight bending forward of the upper edge, and a corresponding convexity of the outer or circumferential part of the summit. Usually the vertical height of the suture which unites the processes above is small (fig. 25); and it sometimes happens that they are not attached by a suture, and there is not a completion of the arch over the included space. This disconnection is not by any means uncommon. The included space is ovoid or obscurely triangular in outline, or it may be decidedly triangular. When there is no arch, the processes are less aslant (fig. 26), and may approach the upright in position. Often the tops of the processes only just touch. The sutures between the processes and the perignathic ridges are very distinct, and often so without benzene (figs. 25 & 26); and each commences at the upward slope of the process from the free edge of the ridge, and passes downwards with a curve which has its convexity towards the base of the process. The suture just comes within the edge of the branchial groove on each side of the ridge.

The peristomial margin within these sutures, which belongs to the ambulacra, is marked by the notches and is perforated by the corresponding pores of the first series of ambulacral plates;

and some of these are to the median line of, or in the inner and peristomial part of, the base of a process (fig. 26). Usually there are the relics of four grooves with their pores (some often absent) on one side of the peristomial edge and on the base of a process, and of three grooves and their pores, more or less complete, in the base of the other process of the arch; that is, ambulacral plates 1–4 and 1–3 in the respective zones. On looking at a process from behind, much crowding of plates and pairs of pores is seen, and at least three pairs of pores, representing as many plates, are placed obliquely at the base and at the inner flank of the process; they (fig. 30) correspond in their position to the pairs of *Echinus*. Hence in *Psammechinus* the base and much of a process is made up of three plates visible from behind, which are the plates 4, 5, and 6, or in the opposite process plates 5, 6, and 7. Besides these, there are the plates seen in front or at the peristomial edge, numbering 1–3 or 1–4. A process in *Psammechinus* may therefore be composed of the oblique and hypertrophied poriferous parts of seven plates.

There is the same disposition to fracture in the processes above the spot of the uppermost externally visible pores; but no sutures can be seen with even the aid of benzene. That there are canals passing out of sight in processes and communicating with pores is evident; for on fracturing a process moderately high up a pair of canal-ends became visible (fig. 31). (This may be also seen in *Strongylocentrotus*.)

The ridges are moderately high and are broadest inferiorly; the upper edge is concave, and there may be swellings on it close to the median line. The branchial grooves and other features of the peristomial face of the ridge are as in *Echinus*. The construction of a ridge is very much the same as in *Echinus* (figs. 27, 28, 29).

V. The Echinometradæ and the Diadematidæ.

Strongylocentrotus lividus, Lmk., sp.—The perignathic girdle of this species is slender; the processes are moderately tall, slender, united above, without much lateral expansion there, and they have narrow and tall openings. There is much crowding of the ambulacral plates at the base of a process; and three or four pairs of pores may be seen from behind to be on the base, back, and inner flank of the process. There are as many plates in front. The ambulacro-interradial sutures of all these

plates are wanting, and the plates merge into the mass of the process. The ridges are low and broad, and are well-marked by the attachment-lines of muscles; and the branchial grooves are well developed.

The interesting and important points in this species and genus are *that the ridge is composed of more than one plate at its free edge, and that two or even three interradial plates may enter into its composition there* (figs. 32, 33, and 34). In fig. 32 it will be observed that the plate 1 of zone *b* has pushed aside plate 1 of zone *a*; and this can be well understood if the nature and position of the first plates of both zones in an *Echinometra* (fig. 35) are studied. When there are three plates at the edge (fig. 33), it will be noticed that the growth of plate 2, zone *a*, has pushed aside the first plate of its zone. Plate 1 of zone *b* is in its normal position.

It will be observed that in zone *a* there are two plates following the first, and that one is low and the other is large. This is the succession as seen in *Echinus* and the Temnopleurids. Again, in the zone *b* the plates, both of which are large, are numbered 3 and 4; and these are the homologues of the two large plates which succeed to the single plate in *Echinus* &c. Plate 2 of this zone has no representative in *Echinus*, unless it is admitted that it is united with the first plates of both zones to form the single large edge-plate in this last-mentioned genus. This must, I think, be admitted. The ridge of *Cidaris* is composed of two plates in one zone, and one in the other; but there is no fusion as in *Echinus*.

As might be expected, there is much crowding of the pairs of pores and of their plates in the base and for some distance up the processes. There are at least three pairs of pores and as many plates to be seen at the back and inner flank of the processes, and all traces of the ambulacro-interradial sutures are, as is usual in all processes, lost. But the next plate in succession has its outer suture forming a part of the ambulacro-interradial (fig. 38). There are the usual plates seen at the peristomial side. Now if the ridge be separated at its junction with the process and ambulacrum, a moderately high face of union is seen (fig. 39). This face is marked by almost vertical lines and with some which are slanting, and each depressed line is the corner between two ambulacral plates; and the rounded projections on the face, and which are bounded in front and

behind by the lines just mentioned, are the interradial projections of the ambulacral plates. Plates 4 and 5 will be seen to have rounded and tall plate-ends which come up to the ambulacral surface just below the position of the figures.

But no other plates come up to the line, and they are all at the base and within the mass of the process. The line marked *x* is of great interest, and in some specimens it is visible without reagents on the peristomial face of the test (fig. 40). In this figure the suture, for such is the inner part of the line, passes towards the median line from the suture between the process and the ridge. In fig. 39 the line of suture *x* passes to the peristome, and it marks the upper surface of the poriferous zone whence the process started.

Echinometra lucunter, Leske, sp.—The most striking part of the perignathic girdle of the species of *Echinometra* is the cap, or top projection of the combined processes (fig. 36). This cap is moderately large in the species now under consideration; and it seems like a growth upon the tops of the processes, which covers each one and joins it with its fellow. But the caps are not new growths, nor are they produced by any additional structures; for benzene fails to detect any divisional line between them and the top and posterior part of the processes. The one structure merges into the other, and the caps are growths of the ordinary tissue of the processes. The direction of the processes is upwards and backwards, so that their tops are much more distant from the polar axis of the test than the peristome. The caps seem to diminish this distance in *E. lucunter*, and they evidently give additional points of attachment to the retractor muscles. The arrangement of the pores and their plates on and in the flank of a process close to its base are very much as in *Strongylocentrotus*; and the suture between the process and the ridge fails to be in contact with at least three ambulacral plates at the back of the process.

The ridges of the girdle are long and low; and they are not made after the type of those of the Echinidæ or Temnopleuridæ, but after that of the allied genus *Strongylocentrotus*.

Two conditions prevail, and in one (fig. 35) what may be called the normal condition is seen; that is, there are two plates at the edge of the ridge above, and one is the first plate of zone *a*, and the other is the first plate of zone *b*, and they are symmetrical.

The median line is short, for the plates are low. In zone *a*

plate 1 is followed by plates 2 and 3; and in zone *b* there is the same succession, but the plates of zone *b* are the largest.

In the other condition (fig. 34) there is almost a complete resemblance to one of the combinations seen in *Strongylocentrotus*, where one of the first plates is very small and much of its normal position is occupied by the second plate of the same zone. Were the plates of this combination which come to the edge of the ridge taller and all combined into one, there would be the counterpart of the single edge-plate of the Echinidæ and Temnopleuridæ; in other words, the large plate 1 of zone *b* and the small plate 1 of the opposite zone combined with plate 2 of zone *a* would form a single plate on the plan of *Echinus*.

In concluding this notice of the girdle of the Echinometradæ, it is necessary to remind naturalists that the most extraordinary processes of *Echinometra subangularis* have a tall rectangular cap. It looks very much like an addition to the processes; and indeed it cannot but be a subsequent development induced by the large retractor muscles which this species requires.

The Diadematidæ. *Diadema setosum*, Gray.—The great width of the ridges, their small height, the slender sloping and connected processes, and the extension of the ambulacral area inwards towards the peristome and beyond the bases of the processes characterize this genus. There is nothing to notice in the processes of unusual nature; but they are readily separated from the ridges; and indeed the specimens sometimes fall to pieces, and show stirrup-shaped pieces which are the arches of processes and the ambulacral bases from which they sprang.

The ridges are interesting; and there is always a low median suture to be distinguished with benzene; but the arrangement of the plates at the free upper edge is very varied.

The diversity is due to the crowding of the plates during the growth of the ridges, and to the consequent absorption and alteration of shape of some of the implicated plates. In one specimen (fig. 41) the plate 1 of zone *b* occupies all its half of the edge; but the corresponding plate of the other zone is small, and so the plate 2 comes in at that half also. These plates are succeeded in the normal manner by others of different dimensions in the two zones. In another specimen (fig. 42) the plate 2 of zone *b* has pushed up and inwards the first plate, which occupies only a small space at the edge near the median line and suture; whilst in zone *a* the plate 2 is very close to the edge, being removed only by a very low plate 1.

In the third specimen (fig. 43) the second plates of both zones come to the edge, and the first plates of both zones are crowded towards the median line and are narrow and tall. This is a complete departure from the type of *Cidaris* and *Echinus*. In fact, the very unsymmetrical method of junction of the plates 1 and 2 in fig. 43 seems to indicate that the first plates might be lost altogether (fig. 49). The sutures between the ridges and processes are easily separated owing to their lamellary condition; and it can be seen, on the face of the junction of the ridge and the process, that there are three plates in the ridge of that side which come to the interradial sutural face (figs. 44 and 47). The part of the ridge which is produced towards the peristome is seen in fig. 45.

Echinothrix Desori, Peters.—This species has exceedingly broad and very low ridges; and in most instances there is a median projection on a ridge at the free curved edge. The ridges are formed by three plates in each zone, instead of one in addition to the usual single and double plate of the different zones (fig. 48). At the edge there is a triangular and small plate with its suture at the median line, slightly departing from the vertical; and the other suture is between this plate (1), zone *a*, and the succeeding low but broad plate 2. But this last plate is oblique, and reaches from the free edge near the process to the median suture. Then comes plate 3, also oblique, and being the usual large plate of the zone. In the other zone, *b* (fig. 38), the first plate occupies the whole of the upper edge of the ridge on its side; and plate 2 is the usual low plate of the zone, and plate 3 is the usual large plate.

The ridge is, then, mainly composed of three plates, two on one side of the median line and one on the other.

There is nothing which requires notice with regard to the processes, except that they are expanded above and have a large opening (fig. 46).

But the bases and the ambulacral plates close by are well worthy of study, for the peculiar distribution of the pairs enables the direction of the plates to be distinguished. Benzene also assists, so that the relation of the suture between the process and the ridge, and its continuation between the ambulacrum and the interradium, can be seen, and the connection of this long line of junction with the ambulacral plates (poriferous part) can be made out.

About nine minor plates have their pores on the inner flank of a process; and none of these plates have their poriferous part limited by suture, and the suture between the ridge and the process is remote from the pores. But all succeeding plates have their poriferous zones in contact with the closely placed ambulacro-interradial suture.

VI. The Suborder Clypeastridæ, &c.

Students of the Echinoidea are under great obligations to A. Agassiz for his revision of the genera and his magnificent plates. His descriptions and illustrations of the Clypeastroids are especially excellent, and the drawings and photographs which represent the internal structure of the species are admirable.

The nature of the jaws of the Clypeastroids will be found in most works on the Echinoidea, and all that is necessary to be mentioned here is to follow Agassiz and state that "The mode of articulation of the jaws upon the auricles is entirely distinct in the Clypeastroids and in the Desmosticha; in the Clypeastroids the auricles are disconnected, and when the jaws are in position they completely hide the auricles on which they ride. The muscular system of the jaws of Clypeastroids is reduced to a very feeble band attached to the underside of the pyramids, and extending to the auricles" (Rev. Ech. p. 689). The figures of *Clypeaster subdepressus* (pls. xxx. and xi. *b*), *Echinanthus rosaceus* (pl. xxviii.), *Clypeaster scutiformis* (pl. xiii. *f*), and *Echinodiscus auritus* (pl. xiii. *c*), &c., show the position of the structures, the muscular fibres being omitted.

I have been able to dissect a specimen of *Laganum depressum* which contained the viscera, and I have had the advantage of studying specimens of *Clypeaster* (*Echinanthus*, A. Ag.) *rosaceus* and *Clypeaster humilis* at the British Museum.

It is quite evident that these three species are not formed upon the same type as regards the supports of the jaws. There is an interesting difference which should be of classificatory value; for whilst in both the forms of *Clypeaster* there are two processes supporting a pyramid, in *Laganum* and also in *Echinarachnius*, *Mellita*, and *Echinodiscus* there is but one support to the fifth part of the whole jaw-apparatus.

Unfortunately all the other genera of the suborder have not been at my command; nevertheless, by taking the two forms of

Clypeaster, and *Laganum* as types, the nature of the relics of the disconnected perignathic girdle can be appreciated.

Clypeaster (*Echinanthus*, A. Ag.) *rosaceus*, Linn.—When the abactinal part of the test is removed and the jaws also, the inner surface of the actinal part is seen, and the five ambulacra are noticed to be broad at the peristomial edge and each commences there with a plate on either side of the ambulacral median line. These plates are perforated by a pair of large pores close to the edge, and all the rest is furrowed from side to side and penetrated by a multitude of very small pores (fig. 53). The side sutures of these ambulacral plates (the ambulacro-interradial) are visible at a short distance from the peristomial edge but not up to it. The interradial plates at the peristomial edge are not one half of the breadth of an ambulacrum there. Benzene shows that there is but one plate in the interradium, whilst there are two to an ambulacrum. See also Lovén, Études, pl. xlvii.* Moreover it is seen that one of the processes of the incomplete and very disconnected perignathic (or rather infragnathic in position) girdle has its narrow base limited on one side by the lateral suture of the interradial plate 1, and that this plate is crushed in between the process and the one on the other side (fig. 54). It is evident that the interradial plate no. 1 is narrow and yet long, from the peristomial edge towards the circumference, or outwards; and it is seen that the second pair of ambulacral plates (plates zone *a* 2 and zone *b* 2) are so broad that they extend right into where there should be interradial plates nos. 2, and unite by suture with the second plates of the next ambulacra (fig. 53). The result is that the plate 1 of the interradia is separated circumferentially from the second pair of interradial plates, which are found further outwards. The interradial plate 1 is not covered by a process, but it is between two processes. A process arises from a narrow but long base (fig. 53, *p*), which is in that part of an ambulacral plate where the numerous pores seem to end without coming up to the ambulacro-interradial suture. The spot is the posterior or circumferential and outer corner of the plate, and it is of course far from the median ambulacral line (fig. 53).

Careful amplification shows that the pores are continued in small pairs, placed rather wide apart, upon the flank of the process

* Lovén, 'Études,' gives admirable dissections of the plates of the Clypeastroids. He does not describe the processes, however.

which is towards the ambulacrum (fig. 55). The process is then a part of an ambulacral plate, and as there are two plates in each ambulacrum at the peristomial edge, so there are ten processes as jaw-supports.

Each process is tall, and has a narrow but long base and flanks; the top is small and more or less oval or circular in outline and is smooth. The general direction of a process is upwards and outwards (towards the circumference), and slightly on one side towards the process on the other plate of the ambulacrum. But there is a bending forward towards the peristome in the direction of the upper third of a process, and the slope of it is much sharper in that direction than in the opposite (figs. 54, 55). The processes which look stout, when seen from their sides, are slender and narrow when seen from the front or peristomially, and in that view their divergence over the narrow interradium is evident.

It would thus appear that the processes of *Clypeaster* are the homologues of the processes of the Glyphostomes, and that the function is not the same. In the Clypeastroids the processes are more or less pivots and underneath supports to the jaws, and the duty of the muscle said to be attached is not apparent, but it may be a retractor.

Clypeaster humilis.—The study of a test of this species at the British Museum proved that there is a close resemblance between the processes and those of *Clypeaster rosaceus*.

The interradial plate at the peristome is, however, better defined than in the instance of *C. rosaceus*, and it projects backwards, so that the posterior edge is seen to be thick and curved, and projecting beyond the first ambulacral plates. In front or towards the peristome the interradial plate is low and narrow, and conforms to the general shape of the peristomial margin (fig. 56).

The processes are not connected with this plate, and it has no growth whatever upon it. The processes are similar to those of *C. rosaceus* in shape and in position; they are growths of the ambulacral plate near the peristome, and arise close to the ambulacro-interradial suture. (Probably the first ambulacral plate of an ambulacrum in the *Clypeasters* is a compound one, but I have not proved it to be so.) It appears that the small pairs of pores which are to be seen on the ambulacral side of a process close to its base in *Clypeaster rosaceus* are not visible in *C. humilis*; but I have not been able to examine a sufficient number

of specimens to be able to state that this distinction is invariable.

With regard to the jaws of *Clypeaster*, it will be remembered that each pyramid has two cavities on its inferior surface, and a process fits into each one and supports the jaws. It is not the two processes of the same ambulacrum which fit into the cavities of the same pyramid, but the process of one ambulacrum and the process of the next ambulacrum which is situated just on the other side of the interradium. So far as I can make out, the muscle starts from the front of a process and reaches a pyramid close above the teeth, and it acts with those of the other processes as an opener of the jaws.

Laganum depressum, Lesson.—On dissecting a specimen it is seen that the ambulacra at the actinal surface have a large pore close to the peristomial edge of each first plate, and that the first plates are large and have a median furrow ending in a swelling between the large pores or slightly externally to them. Numerous rows of minute pores start from close to the median line and reach outwards until a radiating series of small tubercles, five or six in number, is reached. These tubercles are within the interradium and are on the interradial side of the ambulacro-interradial suture. A corresponding series of tubercles is on the other side of the single interradial plate no. 1. This plate is single and fits in between two ambulacra, and it is sutured to two interradial plates circumferentially. See also Lovén, 'Études,' plate xlv.

Now on removing the abactinal part of the test and taking off the jaws, it is at once noticed that the arrangement of the girdle is unlike that seen in *Clypeaster*. There are only five projections instead of ten, and each is curved, concavity towards the peristome, from which it is separated by a distance equal to its own height, which is not great however (figs. 50 & 51). The posterior projections are larger than the other three and are more pointed (fig. 52).

Benzene displays, within, the suturing of the plates which were recognized on the surface. The limits of the ambulacral plates are well defined and they are attached to the sides of the interradial plate no. 1. The pores may be seen on the surface of the ambulacra within, and also some stout transverse lines; but it is evident that the projection has not its base within an ambulacral plate. The projections are growths from the upper surface of the first interradial plates, which are single, in each interradium, at the peristome, and they are therefore homologues of "ridges."

The peristomial face of the ridges (for such they are) is usually marked by a depression on either side of their median line, and the other face is convex. The tops may be rounded, pointed, or rectangular, and the breadth of a process is greater than the measurement from the peristomial face backwards.

There are no traces of small plates in the ridges.

Probably the depressions just mentioned are the points of attachment of muscular fibres, and it is evident that the motions of the jaws must be as restricted in this species as in the true Clypeasters.

On looking at the photographs of *Echinarachnius parma*, *E. mirabilis*, *Mellita testudinata*, and both *Echinodiscus auritus* and *E. biforis* in the 'Revision of the Echini,' by A. Agassiz, it is perfectly evident, after the study of the *Laganum*, that they all have the projections single and one in each interradium, and that they are all homologues of the perignathic ridges of the regular Echinoidea.

VII. Conclusions.

As the structures which give attachment to the muscles which protrude and retract the jaws of the Echinoidea, and which are integral and not additional parts of the test surrounding the peristome within, are not homologous in Cidaridæ, Echinidæ, Clypeastridæ, and Laganidæ, it is impossible to retain the old term of "auricles." As the structures form a perfect girdle around the jaws in Discoidea, and more or less disconnected parts of a girdle in other forms, the term "perignathic girdle" is advisable. The girdle consists of "processes" usually united above, but sometimes, and mostly in young forms, disconnected, and of "ridges" which connect the "processes" on the side remote from the ambulacra.

In the Cidaridæ the muscular attachments are all on perignathic and usually disconnected "ridges," which are modifications of the peristomial interradial plates. The ridge is made up of two plates in one interradial zone (plates 1 and 2), and of one plate (1) in the other, there being a median line. The plates of the ridge are the upward growths of the plates just numbered, and which carry tubercles at the peristomial margin actinally. The "ridges" may overhang so much as to join and arch over the ambulacra, as in the specimen of *Phyllacanthus*.

The Cidaridæ have no "processes."

In the Temnopleuridæ the retractor muscles are attached to "processes," one on each side of an ambulacrum; and they join above in an arched form, and the ambulacrum forms the floor of the arched space.

The processes are growths of the *poriferous portions of the ambulacral plates near the peristome*; and the base of a "process" is united by suture with the "ridge" on the interradium, the line of direction of the suture being along the ambulacral side of a groove on the inner or peristomial face of the ridge which leads to the branchial "cut."

The protractor muscles and the ligament of the radiales are attached to the "ridges." Each ridge has a thin upper edge and is made up of a *single plate* comprising the whole of the free edge; and this is followed in one interradial zone by a low and a moderate-sized plate, and in the other zone by two plates, the first of which is larger than the corresponding plate of the opposite zone.

There is no median line of suture on the ridge; and it is evident that this structure is not made on the same lines as the "ridge" of Cidaridæ.

In *Echinus*, when 5 millim. in diameter, the processes are mere nodules, and each is situated *on the inner surface of the first ambulacral plate and between the first pair of pores and the interradial suture.* It is therefore ambulacral, and is not homologous with the projections noticed by J. Müller on the interporiferous zones of *Cidaris*. With growth, the poriferous zones of the first six or seven plates become implicated in the mass of a process.

The "ridge" consists in the young and old forms of a single plate at the edge, and thus it differs from the ridge of *Cidaris*, which is made up of two plates in one zone, and one in the other. In *Psammechinus* more ambulacral plates enter into the structure of a process than in *Echinus*; and on fracturing a process moderately high up, canals are seen continuous with pores.

The "processes" of the Echinometradæ and Diadematidæ are on the same plan as those of *Echinus*, and the "ridges" differ materially.

The ridges are wide and low, and there is no single plate at the edge as in *Echinus* and the Temnopleurids, but two or more plates. There is in one zone a plate 1, and in the other a plate 1 and part of a plate 2; or, a first plate extends beyond the median

line, and crushes up a small first plate in the other zone. These plates are followed in their respective zones by the plates noticed in the Echinidæ and Temnopleuridæ. It is evident that the single plate of *Echinus* is composed of fused first plates and probably of the low second plate of one zone; so that if the ridge-plates of *Cidaris* were united without any relics of sutures, the solitary plate of the ridge of the Echinidæ and Temnopleuridæ would be exemplified.

The ridges of the Glyphostomes are the homologues of the so-called auricles of the Cidaridæ; but their "processes," which are not in existence in *Cidaris*, give attachment to important retractor muscles which are not much required in this last genus.

In the Clypeastridæ there are disconnected growths which carry the jaws and have slight muscular attachments. In *Clypeaster* there are ten processes, and each one arises *from an ambulacral plate* (or plates), and one process leans somewhat towards the other of its pair over the ambulacrum. There are no interradial structures like ridges. The processes are the homologues of those of the regular Glyphostomes.

In *Laganum* there are five growths, and each arises from a single *first interradial plate*; so they are "ridges," and the homologues of those interradial structures of the Regular Echinoidea.

The Clypeastridæ may be divided into two groups, on account of the presence of processes in one, and of the homologues of ridges in the other. The relation of the single interradial plate at the peristome of many edentulous (or presumedly so) Regular Echinoidea to the single plate of the edge of the ridge in *Echinus* is evident; and this is the result of junction of the two plates 1 with or without the addition of plate 2 of one zone. The distinction between the Cidaridæ and the Glyphostomata is well defined by the perignathic girdles.

DESCRIPTION OF THE PLATES.

All the figures in both Plates are more or less magnified.

Plate XXX.

Fig. 1. *Dorocidaris papillata*, Leske. Interradial ridge and the peristomial face of the first ambulacral plates. Part of a ridge beyond an ambulacrum.

Fig. 2. The ridge of interradium 5, seen from above. The arrow points to

the peristome, and the curved dark line is the free upper edge of the ridge. Zone "*a*" has one plate and "*b*" has two plates in the ridge.

Fig. 3. A diagram of the side view of the ridge; the oblique line of suture "*a*" is between the two ridge-plates of zone "*b*," or rather between plates 1 & 2 of that zone. The first plate carries a small tubercle. The horizontal dotted line is the upper limit of the ambulacral sutural face.

Fig. 4. View of the ridge from behind. Zone "*b*" has two plates; a^* is the level of the lower part of the ridge.

Fig. 5. Interradial ridge of the girdle of *Phyllacanthus imperialis*, Lmk.

Fig. 6. Another form, showing ambulacral plates also.

Fig. 7. Showing arching of ridges over an ambulacrum, and junction in one instance.

Fig. 8. *Goniocidaris geranioides.* A ridge and the peristomial end of an ambulacrum; part of a second ridge.

Fig. 9. *Salmacis bicolor*, Agass. The processes forming an arch, the ridge joined to the processes by a suture "*s*;" "β" the groove of one side of a ridge leading to a branchial cut. The grooves and pores are shown at the peristomial edge of the ambulacrum and in relation to the processes.

Fig. 10. Side view of ridge (diagram); the connection of a tubercle with the plate is shown.

Fig. 11. Back view of the interradium, its plates and ridge, and of more or less complete processes of the girdle. There is no median suture to the ridge-plate which reaches the free edge, and the base of the ridge is seen to be formed by two plates, by nearly the whole of a low plate in zone "*a*," and a part of a large plate in zone "*b*." The pores and their relation to the suture between the process and the ridge are figured.

Fig. 12. Oblique view of a ridge separated from the adjoining process of the ambulacrum (diagram); the sutural face is covered with minute sockets, and there are traces of a suture which indicate that the low plate is really not plate 2, but that the ridge originally consisted of more than one plate towards its free edge. There is no median suture visible. The figures refer to plates, and the letters to zones of the interradium.

Fig. 13. The sutural face of the process which corresponds to the ridge fig. 12. The surface is covered with knobs and the relics of three plates. The part above the sutural face is the side of the process towards the top.

Fig. 14. Side view of the base of a process from the median ambulacral suture. Plates 5 and 6 have their sutures passing from the median line to the line of ambulacro-interradial suture, but the other plates have not.

Fig. 15. *Microcyphus zigzag*, Agass. The peristomial face of a ridge, showing the tuberosities; there is no visible median suture.

Fig. 16. *Echinus norvegicus*, Düb. & Koren. A pair of processes and a ridge.

Fig. 17. A process cut short, the ambulacral median line is indicated, and on the other side of the pairs of pores is the more or less curved ambulacro-interradial sutural line, which is not reached by the plates close to the base of the process.

Fig. 18. View of a ridge from behind; a^* is the line of base-level of the ridge.

Fig. 19. The processes forming an arch in a small specimen.

Fig. 20. Processes of a smaller specimen, not yet joined and low.

Fig. 21. Processes in a very small specimen; they are mere knobs situated on the poriferous zones of the ambulacra.

Fig. 22. Side view of a ridge, showing the presence of two plates.

Fig. 23. The view of the first three plates of one zone of the ambulacrum of the specimen figured in fig. 21, seen from within the test; the ovoid base of the process is indicated "*p*;" the median line of the ambulacrum is where the figures are placed, and the interradium is marked "*in.*"

Fig. 24. The ridge of an interradium of a large specimen; "a^*" is the line where the ridge begins to rise from the upper surface of the interradium.

Fig. 25. *Psammechinus miliaris.* A ridge seen obliquely and two processes of an ambulacrum forming an arch.

Fig. 26. Processes not joined above; see the line of suture between them and the ridge on one side.

Fig. 27. A ridge, peristomial face.

Fig. 28. A ridge from behind and part of the interradium; a^* is the line above which the ridge rises from the interradial level.

Fig. 29. Side view of a ridge, showing sutural lines.

Fig. 30. Back view of the base of a process, showing the pairs of pores and those which are in plates sutured to the ambulacro-interradial suture.

Fig. 31. A broken process, showing tentacular canals within.

Plate XXXI.

Fig. 32. *Strongylocentrotus lividus*, Lmk., sp. View of the back of a ridge: the numbers refer to plates and the letters to zones of the interradium. The line a^* is that of the level of the base of the ridge, and a^{**} refers to the level of a base. See fig. 42.

Fig. 33. A ridge from behind, showing the presence of two no. 1 plates at the free edge, instead of only one as in fig. 32.

Fig. 34. A ridge, back view, showing almost complete exclusion of one of the first plates at the edge.

Fig. 35. *Echinometra lucunter*, Leske. A typical arrangement of the plates of a ridge, seen from behind.

Fig. 36. Outline of the capped processes of *Echinometra lucunter.*

Fig. 37. *Echinometra subangularis*, Leske, sp. The capped processes.

Fig. 38. *Strongylocentrotus lividus.* A process seen from behind and sideways, showing the large and small pores, and that the plates of pairs 4 and 5 reach the ambulacro-interradial suture.

Fig. 39. The ridge has been separated at the suture from the side of a process, and "γ" is the suture-face on the side of the process; "x" is a line which marks the base of the process; and the numerals 4 and 5 are placed over the tops of the interradial ends of the corresponding ambulacral plates.

Fig. 40. A front or peristomial view of a process, showing the limits of plates forming the base of it; "x" is the line of limitation.

Fig. 41. *Diadema setosum*, Gray. A ridge from behind.

Fig. 42. A ridge of another specimen, from behind.

Fig. 43. A ridge showing the encroaching plates 2 on the edge.

Fig. 44. The suture-face at the side of a ridge between it and a process; three plates are seen at their edges in the ridge, and thus the plate at the actinal surface next to the peristome, and which would be counted as plate 1, is really plate 3. It is marked "*a*," and the lamellar condition of the suturing is very distinct.

Fig. 45. The suture-face, showing the lamellar condition and the great projection of the peristomial part or face of the ridge.

Fig. 46. Outline of the processes and wide arch.

Fig. 47. Side view of junction of a ridge and process.

Fig. 48. *Echinothrix Desori*, Peters. The ridge of an interradium from behind, the line "*a**" denotes the commencement of the rise of the ridge.

The black markings are in the positions of the usual depressions on the plates.

Fig. 49. A magnified view of the sutures at the median line of the figure 43.

Fig. 50. *Laganum depressum*, Lesson. View of part of the test, lower part, seen from within at the edge of the peristome. "*A*" is part of an ambulacrum, and "*in*" is the whole of the first interradial plate on which is the small upward projecting homologue of a ridge. The plate is single, and is succeeded by plates 2 of both zones.

Fig. 51. Side view of interradial plate and ridge.

Fig. 52. One of the posterior projections (ridges).

Fig. 53. *Clypeaster* (*Echinanthus*, A. Ag.) *rosaceus*, Linn. Internal view of the actinal part of the test at the peristome. "*A*" is part of the ambulacrum; "*in*" is the single interradial plate; "*p*" is the base of a process.

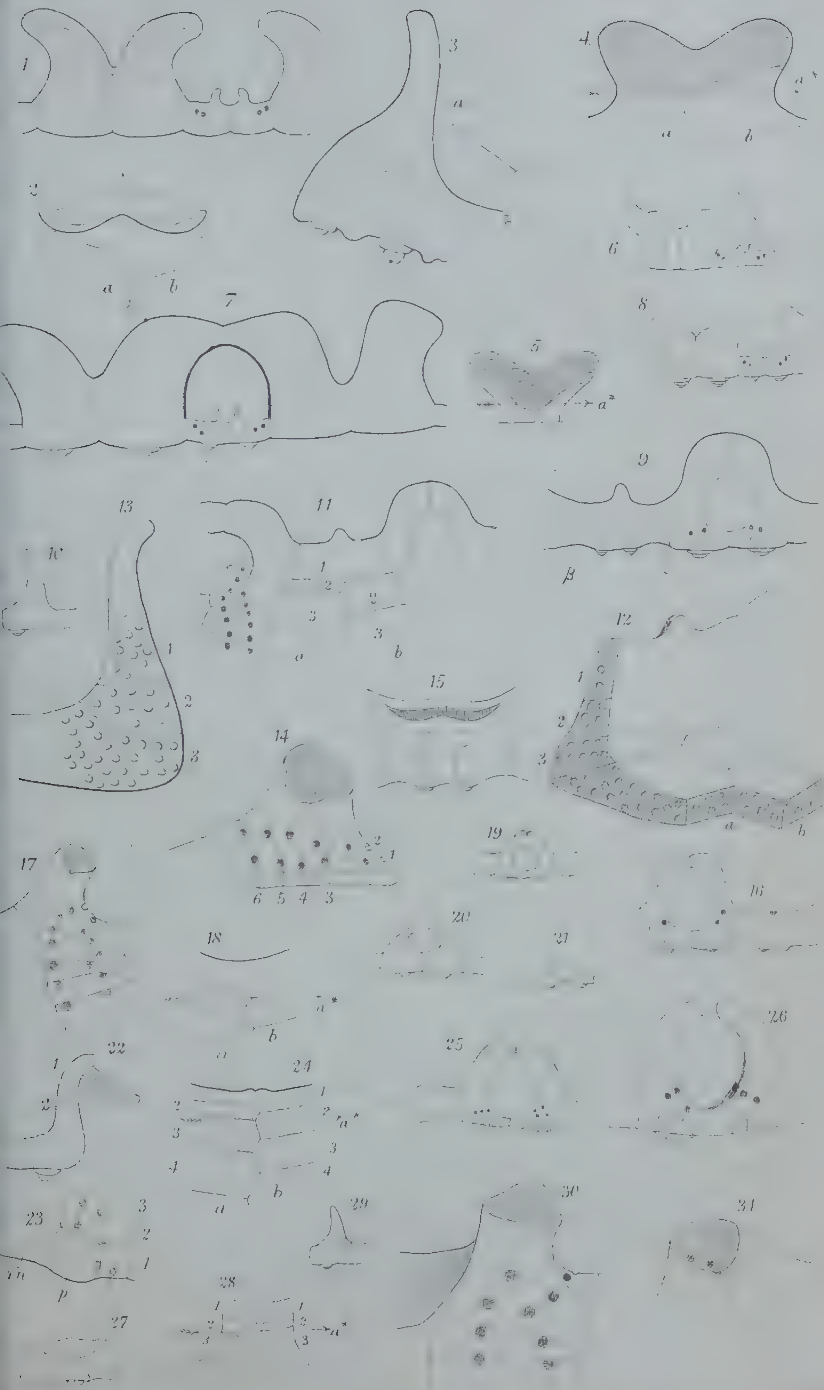
Fig. 54. Processes of neighbouring ambulacra with their bases separated by a narrow interradial plate.

Fig. 55. A view of a process of an ambulacrum, seen from the median ambulacral line outwards. The small pairs of pores are on the flank of the process.

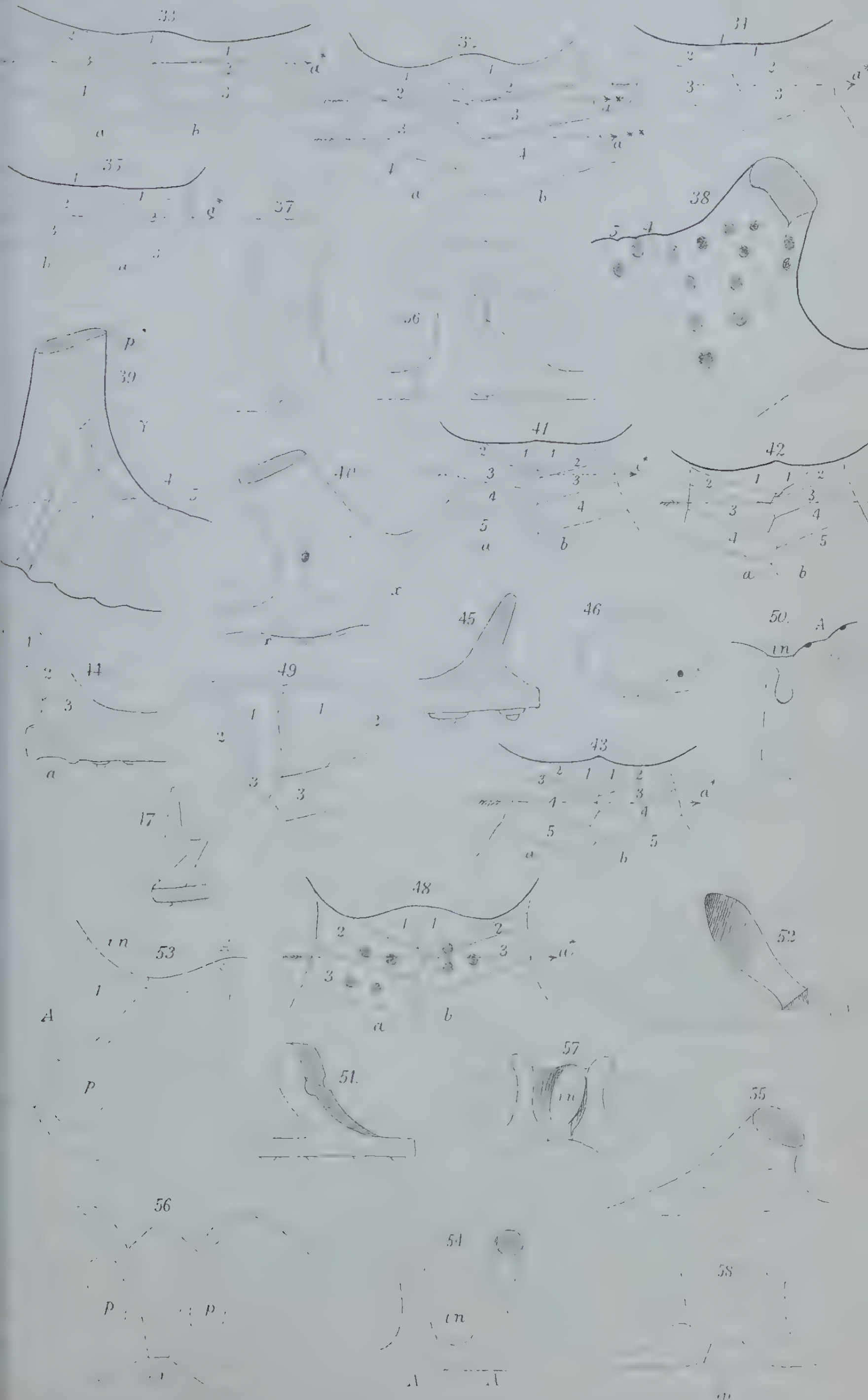
Fig. 56. *Clypeaster humilis*, A. Agass. The actinal part of a test seen from within and at the peristome. The central single plate is the interradial, and it is narrowest at the peristome "*in*." The ambulacra on either side are partly shown, and the bases of the processes of two neighbouring ambulacra are marked "*p*."

Fig. 57. An oblique view of the same surface and specimen, showing the processes and the intervening interradial plate.

Fig. 58. View from behind; "*in*" is the posterior edge of the stout interradial plate, and the plates on either side are ambulacral.



STRUCTURES OF PERIGNATHIC GIRDLE.



STRUCTURES OF PERIGNATHIC GIRDLE.

Carter s

The Colombian Species of the Genus *Diabrotica*, with Descriptions of those hitherto uncharacterized.—Part I. By Joseph S. Baly, F.L.S.

[Read 17th December, 1885.]

In the following paper I have endeavoured to collect together all the species of *Diabrotica* known to me as having been found in Colombia and Venezuela; a large number of those here described were côllected by the late H. Steinheil, who some years since placed his collection of *Galerucinæ* in my hands for determination. The descriptions of his insects, although written at the time, were laid on one side, and from various causes their publication has been delayed up to the present time.

It will be seen that I have divided the genus into two principal sections, dependent on the relative lengths of the second and third joints of the antennæ.

Genus DIABROTICA.

Section I.

Second and third joints of antennæ short, nearly equal in length, the third in some species being rather longer than the second, the fourth as long or longer than the preceding two united.

A. Elytra black or metallic green, with large, round, fulvous spots.

1. Diabrotica regalis, *Baly, Annals & Mag. Nat. Hist.* Oct. 1859, p. 270.

Var. A. Elytris a basi ad pone medium fulvis.

Hab. Coper, Muzo: coll. Steinheil. Colombia, without precise locality: my collection. Var. A. Cayenne: my collection.

2. Diabrotica elegantula. Subelongata, postice paullo ampliata, flava, nitida; capite, scutello, metapectore, tibiis tarsisque nigris; antennarum articulis nono ad undecimum (hujus apice excepto) albidis; thorace subquadrato, rufo-testaceo, disco bifoveolato; elytris crebre punctatis, infra humeros longitudinaliter sulcatis; viridi-æneis, utrisque macula infra basin, fascia prope medium, sæpe utrinque abbreviata, apice limboque laterali, flavis. Long. 3–3½ lin.

Hab. Magdalena River: my collection. Muzo, Sta. Carlos, Coper: collection of H. Steinheil.

Head not longer than broad, triangular; front impressed with a deep fovea; surface of clypeus slightly irregular, carina not defined; antennæ filiform, second and third joints short, the latter slightly longer than the second, the fourth as long as the preceding two united. Thorax subquadrate; sides parallel from the base to beyond the middle, slightly converging at the apex; the anterior angles obtuse, the hinder ones acute; disk smooth and shining, impressed on either side with a shallow fovea. Elytra narrowly oblong, increasing in width from the base towards the middle, closely punctured, faintly sulcate longitudinally below the humeral callus.

In one specimen from the Magdalena River the transverse fascia, which varies greatly in extent in different individuals, is reduced to a small round spot.

3. Diabrotica consentanea. Subelongata, postice paullo ampliata, nigra, nitida; antennarum articulis nono et decimo albidis; femoribus basi, abdomine thoraceque flavis, hoc lævi, disco ante basin deplanato; elytris obsolete rugoso-punctatis, utrisque limbo laterali, ad apicem abbreviato, fascia vix pone medium, utrinque abbreviata, maculisque tribus, duabus infra basin transversim positis, tertia ante apicem, prasinis. Long. $3\frac{1}{2}$–4 lin.

Var. A. Elytris ante medium totis prasinis.

Hab. Muzo, Coper. Var. A: my collection.

Front impressed with a deep fovea; antennæ filiform, the second joint short, the third slightly longer than the second, the fourth equal in length to the preceding two; the ninth and tenth obscure white, stained at their apices with dark fuscous. Thorax about one fourth broader than long; sides nearly parallel and slightly sinuate from the base to just beyond the middle (where they are obtusely angled), thence obliquely converging to the apex, the anterior angles slightly excurved, obtuse, the hinder ones acute; above smooth and shining, the middle disk at its base flattened and faintly depressed. Elytra narrowly oblong, very slightly dilated from the base towards the apex; nitidous, irregularly punctured, the interspaces granulose-punctate; each elytron with the narrow outer limb, abbreviated near the apex, two spots some distance below the base (the first, rotundate, near the suture, the second small, also rotundate, placed close to the lateral limb, but slightly below the first one), an irregular medial transverse band, abbreviated at the suture and the lateral margin, and,

lastly, a subrotundate spot halfway between the middle and the apex, pale grassy green.

In var. A the transverse fascia is replaced by a rotundate spot.

4. Diabrotica gratiosa. Subelongata, postice paullo ampliata, fulva, nitida; metasterno, tibiis, tarsis, scutello capiteque nigris; antennis basi piceis, articulis 9–10 albidis; thorace subquadrato, lævi, rufo-testaceo; elytris sat crebre, evidenter punctatis, infra basin leviter excavatis; cyaneis, limbo laterali, apice ampliato, fascia lata vix pone medium et utrinque macula rotundata ante medium, flavis. Long. 3 lin.

Var. A. Elytris pone medium flavis, et fascia obliqua, utrinque abbreviata, cyanea instructis; macula flava ante medium obsoleta.

Hab. Type, Sta. Carlos: coll. Steinheil. Var. A, Colombia: my collection.

Head not longer than broad, triangular; front impressed with a deep oblong fovea, which extends downwards between the encarpæ, the latter subpyriform, not distinctly separated from the front; carina raised, narrowly wedge-shaped; antennæ filiform, the second and third joints short, equal, the fourth as long as the preceding two; the three lower joints piceous, the ninth and tenth white. Thorax scarcely broader than long; sides straight and parallel from the base to beyond the middle, thence converging to the apex; surface smooth, impunctate. Elytra broader than the thorax, narrowly oblong-ovate, dilated posteriorly; convex, slightly excavated below the basilar space, rather closely and distinctly punctured.

B. Elytra castaneous or rufo-castaneous, their apices nigro-æneous, coarsely rugose; epipleura clothed with bright yellow hairs.

5. Diabrotica chrysopleura, *Harold*, *Col. Hefte*, xiii. 1875, p. 92.

Hab. Sta. Martha, Magdalena River: my collection. La Uga: coll. Steinheil.

All the specimens that I have seen of this species have the elytra rufo-castaneous, with the extreme outer disk and the apices nigro-æneous.

C. Elytra yellow, with small black spots or vittæ.

6. Diabrotica histrionica. Subelongata, postice ampliata, pallide flavo-fulva; metasterno, scutello capiteque (antennis exceptis) nigris; thorace subquadrato, lævi, bifoveolato, rufo-piceo, fulvo marginato;

elytris tenuiter punctatis, flavis, maculis 11—3 basi, harum una communi, 4 ante medium et 4 inter medium et apicem positis, nigris ornatis; fascia male definita vix pone medium, interdum interrupta, maculaque apicali suffusa pallide rufo-piceis. Long. 3 lin.

Var. A. Thorace pallide, elytrorum signaturis rufo-piceis obsoletis.

Hab. Colombia: my collection. Var. A. Oceana: coll. Steinheil.

Head not longer than broad; front impressed above the encarpæ with a deep fovea; encarpæ thickened, contiguous; carina raised, very narrowly wedge-shaped; antennæ filiform, entirely fulvous; the second and third joints very short, nearly equal, the fourth as long as the two preceding united. Thorax rather broader than long; sides rather broadly margined, parallel and sinuate from the base to beyond the middle, thence converging to the apex, all the angles produced, subacute; disk moderately convex, bifoveolate, shining, impunctate, more or less stained with rufo-piceous, in highly coloured specimens the entire disk being piceous, with the limb obscure fulvous. Elytra broader than the thorax, dilated posteriorly, convex, rather closely and distinctly punctured, pale yellow, marked with eleven bluish-black spots: of these three are larger than the rest and subquadrate, placed at the base—one on either elytron covering the humeral callus, and a third common, surrounding the scutellum; the eight others form two slightly curved transverse rows, one just before the middle, the other halfway between the middle and the apex; the rufo-piceous markings vary greatly in extent, and are sometimes entirely wanting

7. Diabrotica spilota. Subelongata, postice paullo ampliata, flavo-fulva, nitida; pectore capiteque (antennis exceptis) nigris; thorace rufo-fulvo, lævi, disco non foveolato; elytris minute sat crebre punctatis, flavis, maculis 11—3, 4, 4—ut in *D. histrionica* dispositis, cæruleo-nigris aut nigris. Long. 3 lin.

Var. A. Elytrorum macula basali communi obsoleta.

Hab. Venezuela, Mexico, and Oceana (*Landolt*).

Very similar in coloration and in the pattern of its elytra to *D. histrionica*; its thorax is smooth and impunctate; the discoidal foveæ, present in the former species, are obsolete; the rufo-fulvous markings on the elytra are rarely wanting.

8. Diabrotica nigronotata. Ovata, postice ampliata, valde convexa, flava, nitida; tibiis, tarsis, metasterno, scutello capiteque nigris; antennis pallide piceis; thorace quam longiore vix latiori, convexo,

nitido; elytris oblongis, apicem versus paullo ampliatis, convexis, subcrebre punctatis, maculis 15 (3, 4, 4, 4 transversim dispositis) nigris, ornatis. Long. 4 lin.

Hab. La Luzula; also Ecuador.

Head distinctly longer than broad, subtriangular, nearly impunctate; antennæ slender, the second and third joints very short, nearly equal, the fourth joint slightly longer than the preceding two united. Thorax scarcely longer than broad; sides nearly parallel, converging near the apex, sinuate from the base to beyond the middle; above transversely convex, subconic near the apex, smooth, impunctate. Elytra convex, distinctly but not closely punctured, marked with fifteen large black spots, arranged in four transverse rows—three at the base, the middle one common, four just before and four immediately behind the middle, and, lastly, four midway between the last row and the apex; this row is sometimes obsolete.

9. Diabrotica Dysoni. Elongato-ovata, postice vix ampliata, convexa, flava, nitida, metapectore capiteque nigris; antennarum articulis antepenultimo et penultimo fulvis, labio piceo, mesosterno, scutello thoraceque rufo-fulvis piceo tinctis; thorace lævi, leviter bifoveolato; elytris distincte sed tenuiter punctatis; vittis tribus, a basi fere ad medium extensis, vitta media communi et utrisque maculis oblongis duabus pone medium positis, cyaneo-nigris. Long. 3 lin.

Hab. Colombia (*Dyson*).

Head not broader than long; antennæ filiform, the second and third joints short, the latter scarcely one half longer than the second, fourth joint as long as the preceding two united. Thorax one half broader than long; sides parallel and sinuate from the base to beyond the middle, thence obliquely converging to the apex; disk transversely convex; middle disk flattened, obsoletely bifoveolate. Elytra oblong, very slightly increasing in width posteriorly, convex, faintly depressed near the suture below the basilar space, finely but distinctly punctured; surface with three nigro-cyaneous vittæ, placed transversely at the base and extending nearly to the apex, the middle one sutural, common, the lateral ones covering the humeral calli; in addition, placed transversely on the hinder disk of each elytron, are two similarly coloured patches, the inner one oblong, the outer elongate.

This insect may be known from any of the similarly coloured species by the short third joint of the antenna.

D. Elytra flavous, narrowly margined with black.

10. DIABROTICA LIMBELLA. Ovata, postice ampliata, convexa, flavofulva, nitida; pectore, pedibus (femoribus basi exceptis), scutello capiteque nigris; antennis basi piceis, articulis tribus ultimis sordide albidis; thorace lævi, dorso non foveolato; elytris subcrebre punctatis, anguste nigro limbatis. Long. $3\frac{1}{2}$ lin.

Hab. Colombia: a single specimen in my collection.

Head scarcely longer than broad, triangular; antennæ slender, filiform, the second joint short, ovate, the third one half longer than the second, the fourth as long as the preceding two united. Thorax nearly one half broader than long; sides parallel and sinuate from the base to beyond the middle; upper surface transversely convex, not foveolate. Elytra ovate, dilated posteriorly, convex, distinctly punctured; the entire limb of each elytron narrowly edged with black.

11. DIABROTICA NIGROLIMBATA. Elongata, postice vix ampliata, convexa, nigra, nitida, antennis basi sordide flavis; abdomine thoraceque flavis, hoc lævi; elytris sat crebre punctatis, flavis, nigro limbatis. Long. $2\frac{2}{3}$ lin.

Hab. Paine; Muzo.

Head scarcely longer than broad, triangular; vertex shining impunctate; front impressed above the encarpæ with a large fovea; encarpæ ill-defined; carina linear; antennæ filiform, the second and third joints short, the latter nearly one half longer than the former, less than half the length of the fourth; three lower joints obscure flavous, stained above with piceous. Thorax nearly one fourth broader than long; sides straight and parallel, slightly converging at the apex; disk shining, impunctate. Elytra subelongate, broader than the thorax, very slightly dilated from the base towards the apex, the latter broadly rounded; above convex, closely and distinctly punctured.

E. Elytra with the basal margin and a narrow curved line below the middle cyaneous.

12. DIABROTICA ARCUATA, *Baly, Ann. Nat. Hist.* 3 ser. iv. 1859, p. 271.

Hab. Bogota; Magdalena River.

F. Elytra flavous, with a black or dark metallic blue annulus on the anterior disk and a second below the middle, the latter usually incomplete.

13. Diabrotica inæqualis. Elongato-ovata, postice ampliata, convexa, pallide fulva, nitida; postpectore, tibiis tarsisque nigris; capite nigro-æneo; antennis nigris, articulis ultimis tribus (ultimi apice excepto) albidis; thorace fulvo, late excavato, trifoveolato; elytris oblongis, postice paullo ampliatis, leviter rugulosis, tenuiter punctatis, subtiliter elevato-vittatis, spatiis inter vittas obsolete sulcatis, costis duabus infra humerum magis fortiter elevatis, interspatio inter illas costas magis profunde sulcato; nitido-flavis, utrisque vitta brevi basali, communi, altera curvata, super callum humeralem posita, fasciaque brevi arcuata, medio interrupta, inter medium et apicem sita, viridi-æneis. Long. $3\frac{1}{4}$ lin.

Hab. Magdalena River.

Head not longer than broad, trigonate; mouth and antennæ black, the latter filiform, the third joint one half longer than the second, the fourth equal in length to the previous two united; four lower joints piceous, stained above with black, the three outer joints, the apex of the upper one excepted, pale yellowish white. Thorax scarcely one half broader than long; sides parallel and sinuate from the base to beyond the middle, thence rounded and converging to the apex; disk shining; hind disk broadly excavated, more deeply foveolate on either side and at the base. Elytra oblong, dilated posteriorly, convex, faintly wrinkled; each elytron with six or seven slightly raised vittæ, which are rendered less distinct owing to the irregular wrinkles of the whole surface; the spaces between the costæ subsulcate; two costæ below the humeral callus are more strongly raised than the rest, the space between them being more deeply sulcate; a short vitta at the base of the suture, another, curved, on the humeral callus, together with a short, narrow, curved fascia, interrupted in the medial line, placed between the middle and apex, bright metallic green.

The wrinkled elytra, together with the black tibiæ and tarsi, will at once distinguish the present species from most of its allies. It is probable that in some specimens the basal metallic markings are prolonged and confluent, forming a regular annulus, as in *D. biannularis.* It is closely allied to *D. Haroldi.*

14. Diabrotica Haroldi. Oblongo-elongata, postice paullo ampliata, fulva, nitida; postpectore, tibiis, tarsis capiteque nigris; antennis

apice sordide albidis, basi piceis; thorace quam longiori vix latiori, disco excavato, distincte bifoveolato; scutello piceo; elytris lævibus crebre punctatis, utrisque annulo subbasali lineaque arcuata pone medium, nigro-cyaneis. Long. $3\frac{1}{2}$ lin.

Hab. Colombia.

Head not longer than broad, triangular; antennæ filiform, the second joint short, the third one half longer than the second, the fourth equal in length to the preceding two united. Thorax scarcely broader than long; sides parallel and slightly sinuate from the base to beyond the middle, thence slightly converging to the apex; disk broadly excavated, distinctly bifoveolate. Elytra narrowly oblong, moderately convex, smooth, closely punctured.

15. Diabrotica biannularis, *Harold, Coleopt. Hefte*, xiii. p. 91.

Hab. Colombia; also Mexico and Guatemala.

The third joint of the antenna is quite one half longer than the second; the apical joint in the Colombian specimens is scarcely darker than the preceding ones. The pale tibiæ separate this species from *D. Haroldi*.

G. Elytra flavous or fulvous, with irregular black markings, sometimes almost entirely flavous.

16. Diabrotica tarsalis, *Harold, Coleopt. Hefte*, xiii. 1875, p. 92.

Hab. Bogota (*Steinheil*); Magdalena River: my collection.

This species varies greatly in the pattern of its elytra; in some specimens they are fulvous, with small irregular black markings.

H. Elytra green or yellowish green, immaculate, or with black, piceous, or flavous markings.

17. Diabrotica 10-punctata, *Latr. Voy. Humb.* ii. 1833, p. 21, t. 39. fig. 9.

Hab. Paine; Fusagasuga; La Luzula; Eastern Colombia (*Winkler*). Magdalena River; Bogota.

18. Diabrotica placida. Ovata, postice paullo ampliata, flavo-viridis; scutello, capite, pectore pedibusque nigris, abdomine flavo; thorace subquadrato, lævi; elytris tenuiter crebre punctatis. Long. 3 lin.

Hab. Ubaque, La Pavos; Rio Negro.

Head triangular, not longer than broad; vertex impressed on either side with very fine transverse strigæ; front just above the encarpæ with a deep fovea; encarpæ well defined, trigonate, contiguous; lower portion of clypeus with a transverse ridge, from the upper edge of which an ill-defined, narrowly wedge-shaped carina extends upwards to the encarpæ; labrum large; antennæ nearly equal to the body in length, filiform, the second and third joints short, nearly equal, the fourth longer than the preceding two united. Thorax about one fifth broader than long; sides parallel and distinctly sinuate from the base to beyond the middle, slightly dilated and rounded anteriorly, converging near the apex; disk smooth and shining, nearly impunctate. Elytra oval, dilated posteriorly, convex, rather closely and distinctly punctured, the interspaces granulose.

This species must stand close to *D. 10-punctata*, Latr. It is rather smaller, the third joint of the antenna is shorter, and the elytra are immaculate.

19. DIABROTICA SUBSULCATA, *Baly, Trans. Ent. Soc.* 3 ser. ii. 1865, p. 351.

Hab. Colombia, Bogota.

20. DIABROTICA BIPUSTULATA. Oblongo-ovata, postice paullo ampliata, convexa; prasina, nitida; ore, antennis, abdomine, tibiis et tarsis anticis quatuor, pedibusque posticis totis, sordide fulvis; thorace bifoveolato; elytris crebre punctatis, leviter sulcato-vittatis; utrisque pustula transversa, vix pone medium oblique posita, apiceque extremo fulvis. Long. 3 lin.

Hab. Venezuela: my collection.

Head subrotundate; vertex impressed with a deep longitudinal fovea; second and third joints of antennæ very short, equal, basal joint pale green. Thorax distinctly broader than long; sides parallel and slightly sinuate from the base to beyond the middle, thence obliquely converging towards the apex; disk smooth, impressed just behind the middle with a shallow semilunate excavation, deeper at either end, and there forming a distinct fovea. Elytra oblong, slightly dilated posteriorly; convex, each elytron with five or six faintly impressed longitudinal sulcations.

21. DIABROTICA LEBASII. Anguste ovata, postice ampliata, convexa, pallide piceo-fulva; scutello, oculis antennarumque articulis septimo

ad nonum ultimoque nigris; thorace bifoveolato; elytris crebre punctatis, limbo externo anguste flavo. Long. $3\frac{1}{4}$ lin.

Var. A. Antennarum articulo decimo nigro.

Mas. Antennarum articulis 3–5 paullo incrassatis.

Hab. Colombia.

Head rather longer than broad, and somewhat wedge-shaped; antennæ filiform, the third to the fifth joints obsoletely thickened in the male, second and third very short, nearly equal, the fourth longer than the preceding two united. Thorax about one third broader than long; sides parallel and slightly sinuate from the base to beyond the middle, thence converging to the apex; disk impressed with two distinct foveæ. Elytra oblong, gradually dilated towards the apex, closely punctured.

22. Diabrotica amabilis. Elongato-ovata, pallide prasina, nitida; capite, metapectore, tibiis tarsisque nigris; antennis sordide fulvis, articulo basali prasino; thorace subquadrato, dorso bifoveolato; elytris tenuissime subcrebre punctatis. Long. $2\frac{1}{2}$ lin.

Var. A. Antennis piceis.

Hab. Magdalena River: my collection. Var. A. Coper: coll. H. Steinheil.

Clypeus clothed with a few silky hairs; antennæ filiform, nearly equal to the body in length, second and third joints very short, equal, the fourth as long as the two preceding united. Thorax subquadrate; sides straight and parallel, converging at the apex; disk impressed on either side with a deep fovea. Elytra finely but distinctly punctured, the punctures piceous, not closely crowded, nearly obsolete at the apex.

In var. A the whole colouring of the insect is darker in all its parts than in the type.

23. Diabrotica simulans. Anguste ovata, postice paullo ampliata, convexa, nitida, sordide flava, viridi tincta; metasterno, tibiis, tarsis, scutello capiteque nigris, antennis pallide piceis; thorace quam longiori paullo latiori, disco medio obsolete transversim excavato, leviter bifoveolato; elytris tenuiter punctatis. Long. $2\frac{2}{3}$ lin.

Hab. Eastern Colombia (*Winkler*).

Head longer than broad, wedge-shaped; vertex impunctate; front impressed above the encarpæ with a deep fovea; encarpæ contiguous, subpyriform; carina raised, linear; clypeus transversely excavated on either side; antennæ filiform, the second and

third joints short, equal, the fourth longer than the preceding two united; the three lower joints, together with the upper two, piceo-fulvous, the rest pale piceous. Thorax rather broader than long; sides parallel, sinuate behind the middle, converging at the apex; disk smooth, impunctate, obsoletely excavated transversely across the middle, impressed on either side with a shallow fovea. Elytra oblong, dilated posteriorly, convex, faintly depressed below the basilar space, minutely punctured.

This insect may possibly be only a variety of the preceding species, in which the thorax is less deeply excavated.

24. Diabrotica labiata. Anguste ovata, pallide prasina, nitida; capite femoribusque viridi-flavis; tibiis, tarsis, antennisque piceo-fulvis, harum articulo basali prasino; metapectore labroque nigris, scutello piceo; thorace quam longiori paullo latiori, utrinque leviter bifoveolato; elytris sat crebre, tenuiter punctatis. Long. $2\frac{5}{6}$ lin.

Hab. Cartago.

Carina distinct; front impressed with a deep fovea; second and third joints of antennæ short, the third slightly longer than the second, scarcely more than half the length of the fourth. Thorax rather broader than long; sides sinuate and parallel from their base to beyond the middle, thence obliquely converging to the apex, the anterior angle slightly excurved, obtuse, the hinder one acute; disk smooth and shining, impressed on either side with a shallow fovea. Elytra oblong-ovate, slightly impressed below the basilar space, finely punctured.

25. Diabrotica virescens. Anguste elongato-ovata, convexa, postice vix ampliata, pallide flavo-virescens, nitida; tibiis piceo-tinctis, tarsis piceis; capite sordide flavo, antennis piceis; thorace lævi, pallide virescente, utrinque sat profunde foveolato; elytris crebre rugoso-punctatis, obsolete elevato-costatis, sordide flavis; utrisque vitta lata suffusa a paullo infra basin ad apicem extensa, viridi, linea suturali, alteraque submarginali, hac ante apicem abbreviata, piceis. Long. 2 lin.

Hab. Colombia, without precise locality: my collection.

Head scarcely longer than broad, triangular, eyes large, black; vertex smooth, impunctate; front impressed just above the encarpæ with a distinct fovea; encarpæ thickened, contiguous; carina raised, gradually narrowed towards the apex; antennæ moderately robust, filiform, the second and third joints very short, equal, the fourth more than equal in length to the two preceding

united. Thorax subquadrate; sides rather broadly margined, parallel and obsoletely sinuate from the base to beyond the middle, thence slightly and obliquely converging to the apex; surface impunctate, middle disk flattened, impressed on either side with a deep fovea. Elytra broader than the thorax, oblong-ovate, slightly dilated posteriorly, convex, closely rugose-punctate; each elytron with four or five indistinctly raised longitudinal costæ.

26. Diabrotica inconstans. Anguste oblongo-ovata, postice paullo ampliata, prasina, nitida; scutello, tibiis tarsisque piceis; ore nigro; antennis piceo-fulvis extrorsum infuscatis; thorace lævi, bifoveolato; elytris sat crebre et fortiter punctatis, obsolete longitudinaliter sulcatis; plagis suffusis duabus, una infra basin, altera pone medium, flavis, plus minusve piceo maculatis. Long. $2\frac{1}{2}$ lin.

Hab. Manizales, Ubaque; Oceana (*Landolt*); Magdalena River; also Nicaragua and Mexico.

Head not longer than broad, triangular; antennæ filiform, the second and third joints short, nearly equal, the latter being only slightly longer than the former; fourth much longer than the two united. Thorax one half broader than long; sides nearly straight and parallel from the base to just beyond the middle, thence obliquely converging to the apex; upper surface minutely and remotely punctured; disk bifoveolate. Elytra oblong, slightly dilated posteriorly, convex, strongly punctured; disk of each elytron with four or five broad shallow longitudinal sulcations, the outer one more deeply excavated than the rest; the flavous patches are ill-defined and vary greatly in extent, sometimes covering nearly the whole surface of the disk; in some specimens also the outer limb is edged with flavous; the piceous markings vary equally with the patches themselves, sometimes being entirely obsolete.

Very closely allied to *D. porracea*, Harold; possibly a local form of that species.

27. Diabrotica ornatula. Elongata, pallide prasina, pectore antennisque (harum articulo basali excepto) pallide piceis, femoribus posticis basi, metasterno abdomineque flavis; thorace lævi, tenuiter punctato, bifoveolato; elytris crebre punctatis, elevato-vittatis, basi pustulaque subapicali flavis; fascia basali extrorsum abbreviata, et utrinque maculis duabus transversis, una prope medium, alteraque super pustulam flavam positis, piceis aut rufo-piceis. Long. $2\frac{1}{2}$ lin.

Var. A. Elytrorum maculis plus minusve obsoletis.

Hab. Magdalena River; Muzo; Medellin: my collection. Amalfi: collection of H. Steinheil. Also Mexico, New Granada, Ecuador, and the Amazons.

Antennæ filiform, second and third joints of antennæ very short, equal, the fourth nearly as long as the three basal joints united. Thorax subquadrate; sides parallel, very slightly sinuate, slightly converging at the apex; disk very minutely but not closely punctured, impressed on either side with a large deep fovea. Elytra narrowly oblong, closely punctured, each with four or five raised longitudinal vittæ, obsolete at base and apex, their interspaces concave.

Very close to *D. inconstans*, agreeing in the sculpturing of the elytra, but differing in the coloration, which in the present species is fairly constant. The basal fascia is in some specimens divided into two patches, one on each elytron.

28. Diabrotica mutabilis. Anguste oblonga, postice vix ampliata, convexa, prasina, nitida; abdomine flavo; capite, scutello pectoreque nigris, tibiis tarsisque piceo-nigris; antennis piceis, articulis ultimis tribus sordide fulvis; thorace quam longiori paullo latiori, dorso obsolete bifoveolato; elytris oblongis, sat crebre punctatis, basi fasciaque vix pone medium posita, nigris; disco pone fasciam interdum fulvo tincto.

Long. 3 lin.

Mas. Antennis magis robustis, articulis intermediis paullo incrassatis.

Fœm. Antennis gracilibus, filiformibus.

Var. A. Elytrorum plaga subbasali alteraque pone medium flavo-fulvis, tibiis fulvis.

Var. B. Elytris totis prasinis.

Var. C. Elytris flavis, prasino limbatis.

Hab. Medellin, Magdalena River, Bogota. Var. C. Caracas (*Thieme*). Venezuela.

Head scarcely longer than broad, subrotundate; clypeus with a longitudinal ridge; front impressed with a deep fovea; second and third joints of antennæ short, equal. Thorax broader than long; sides parallel and slightly sinuate from the base to beyond the middle, thence obliquely converging to the apex; upper surface nearly impunctate, transversely convex, flattened on the disk, obsoletely bifoveolate. Elytra oblong, convex, rather coarsely punctured; humeral callus with a short, ill-defined longitudinal ridge.

29. Diabrotica Gemmingeri. Anguste oblonga, postice paullo ampliata, convexa, læte viridis, nitida; abdomine flavo; pectore, femoribus apice, tibiis, tarsis, scutello capiteque nigris; antennarum articulis

duobus penultimis albidis; thorace bifoveolato, elytris tenuissime punctatis, fascia lata basali, alteraque vix pone medium, extrorsum abbreviatis, nigris. Long. $2\frac{2}{3}$ lin.

Hab. La Pavas; Fusagasuga.

Very similar to *D. mutabilis*; elytra rather more finely punctured; the antennæ in the female (the only sex known) black, the ninth and tenth joints white.

30. Diabrotica formosa. Anguste ovata, postice vix ampliata, prasina, nitida; capite, scutello, pectore, tibiis tarsisque nigris; coxis flavis; antennarum articulo basali prasino, articulis antepenultimo et penultimo albidis; thorace bifoveolato, angulis anticis discique maculis flavis; elytris distincte punctatis, plaga magna basali, communi, fere ad marginem externum extensa, alteraque subrotundata pone medium, aurantiaceis; macula communi basali, secunda super callum humeralem tertiaque maculæ aurantiacæ medio positis, brunneis. Long. 3 lin.

Hab. Venezuela, a single specimen.

Head longer than broad, triangular; antennæ slender, second and third joints very short, nearly equal, the fourth as long as the preceding two united; basal joint pale green, its apex, together with the following three joints, piceous, the fifth to the eighth together with the apical one black, the ninth and tenth white. Thorax one half broader than long; sides parallel and sinuate from the base to beyond the middle, thence converging towards the apex; upper surface very minutely punctured, very remotely punctured on the disk, rather deeply bifoveolate; on the hinder disk is a third, very small, fovea. Elytra distinctly punctured, impressed below the humeral callus with an ill-defined longitudinal sulcation.

31. Diabrotica viridi-pustulata. Anguste oblonga, postice vix ampliata; viridis, nitida; postpectore, pedibus (coxis femoribusque basi exceptis), capite scutelloque nigris; thorace transverso-quadrato, lævi, utrinque foveolato; elytris crebre punctatis, disco exteriori obsolete elevato-vittatis, inter vittas longitudinaliter sulcatis, nigris, plaga magna prope medium, utrinque vix abbreviata, maculaque subapicali, subrotundata, viridibus. Long. $2\frac{1}{2}$ lin.

Hab. Coper: a single specimen in coll. Steinheil.

Front impressed with a deep fovea; encarpæ transverse, contiguous; carina elevated, linear; antennæ filiform; second and third joints short, the third nearly one half longer than the second, less than half the length of the fourth; eight lower joints black (*the three upper joints wanting*). Thorax transverse-quad-

rate; sides parallel, slightly sinuate, very slightly and obtusely angled before the middle, thence slightly converging to the apex, the anterior angles obtuse; disk impressed on either side with a large shallow fovea. Elytra oblong, scarcely dilated posteriorly, granulose, closely punctured; outer disk with three or four obsoletely thickened vittæ, the spaces between longitudinally concave, the interspace below the humeral callus more deeply excavated than the others; the anterior green patch forms a broad medial fascia, abbreviated on the extreme lateral and sutural margins.

32. Diabrotica Chapuisi. Anguste oblonga, postice paullo ampliata, viridis, nitida; postpectore, pedibus, coxis, femoribusque (his basi exceptis), capite scutelloque nigris; thorace subquadrato, lævi, utrinque obsolete foveolato; elytris crebre punctatis, infra callum humeralem breviter longitudinaliter sulcatis; nigris, fascia communi prope medium, ad limbum externum abbreviata, apiceque viridibus. Long. 2½ lin.

Hab. Paine: unique in the collection of H. Steinheil.

Front impressed with a deep fovea; carina raised but not well defined; antennæ filiform, black, the basal joint piceous beneath; second and third joints short, nearly equal; fourth longer than the preceding two united. Thorax slightly broader than long; sides straight and parallel, indistinctly angled before the middle, thence obliquely converging to the apex, apical angles obliquely truncate; upper surface smooth and shining, faintly impressed on either side with a very shallow ill-defined fovea. Elytra broader than the thorax, slightly increasing in width from the base towards the apex, closely punctured, interspaces granulose, longitudinally sulcate below the humeral callus.

33. Diabrotica Sallei. Elongato-ovata, convexa, nitida, subtus flava; prosterno prasino, scutello metasternoque nigris, hoc griseo sericeo, tibiis tarsisque piceis; supra prasina, capite rufo-piceo, antennis sordide fulvis; thorace lævi, utrinque fovea sat profunda impresso; elytris tenuiter subcrebre punctatis; utrisque limbo laterali, apice, maculis duabus infra basin, his transversim positis, fasciisque duabus, utrinque abbreviatis, una vix ante medium, altera inter medium et apicem, flavis. Long. 2 lin.

Hab. A single specimen from Colombia in H. Steinheil's collection; also Guatemala, my collection.

Front impressed just above the encarpæ with a large deep fovea; encarpæ thickened, transverse, contiguous; carina raised, well defined, narrowly elongate; antennæ filiform, the third joint about one fourth longer than the second, scarcely more

than half the length of the fourth; labrum dark piceous. Thorax more than one half broader than long; sides sinuate and parallel behind the middle, rounded just above the latter, thence converging to the apex; disk smooth, impunctate, impressed on either side with a deep fovea. Elytra broader than the thorax, oblong-ovate, slightly dilated from the base towards the apex, the latter broadly rounded; above moderately convex, faintly excavated below the basilar space, finely punctured; each elytron with the apex, the outer limb, and two spots placed transversely just below the base, yellow—one spot, rotundate, is placed between the humeral callus and the suture; the other wedge-shaped, covers the lower half of the humeral callus, its narrow apex extending upwards along the outer border of the callus and being sometimes confluent with the outer limb; in addition, on the disk of each elytron are two concolorous fasciæ abbreviated at either end, one just below the middle, the other half way between the middle and the apex.

34. Diabrotica hexaspilota. Elongato-ovata, pallide prasina; capite piceo-fulvo, metathorace antennisque (harum articulo basali prasino excepto) piceis; labro, tibiis tarsisque nigris; thorace transverso, utrinque leviter foveolato; elytris sat crebre punctatis, utrisque macula subbasali, super callum humeralem, piceo tincta, duabusque parvis juxta suturam, una prope medium, altera inter medium et apicem, flavis. Long. $2\frac{1}{2}$ lin.

Hab. Ubaque.

Front impressed with a deep fovea; carina ill-defined; antennæ filiform, second and third joints short, the latter slightly longer than the former, much shorter than the fourth. Thorax scarcely one fourth broader than long; sides parallel from the base to beyond the middle, thence obliquely converging to the apex, the anterior angles obtuse, the hinder ones acute; disk smooth and shining, impressed on either side with a shallow fovea. Elytra oblong-ovate, minutely but rather closely punctured.

35. Diabrotica virginella. Elongato-ovata, convexa, prasina, nitida; capite, scutello, tibiis tarsisque nigris; abdomine flavo; thorace lævi, disci medio excavato, obsolete bifoveolato; elytris distincte subcrebre punctatis, linea suturali vittaque submarginali, ante apicem abbreviata, basi linea brevi cum connexa, nigris. Long. 3 lin.

Hab. Venezuela: a single specimen from the late Mr. Saunders's collection.

Head longer than broad, triangular; basal joint of antennæ

piceous beneath (the rest of the joints broken off). Thorax scarcely one half broader than long; sides parallel and nearly straight from the base to beyond the middle; upper surface smooth, excavated on the middle disk, faintly bifoveolate. Elytra oblong, distinctly punctured.

I. Elytra metallic green, their apices rufo-piceous.

36. Diabrotica suffusa. Elongata, convexa, piceo-fulva, nitida; tibiis, tarsis, oculis antennisque nigris; thorace lævi; elytris parallelis, crebre subfortiter punctatis, sordide viridi-cyaneis, limbo laterali angusto apiceque pallide rufo-piceis. Long. 4 lin.

Var. A. Elytris fere totis rufo-piceis.

Hab. Fusagasuga; Oceana (*Landolt*).

Head not longer than broad, triangular; eyes very large, prominent; vertex smooth, impunctate; encarpæ contiguous, subpyriform; carina short, strongly raised, linear, terminating below on a strongly raised transverse ridge, which extends across the lower part of the clypeus. Antennæ filiform, in the male equal to the body in length, shorter in the other sex, the second joint short, obovate, the third nearly twice the length of the second, scarcely more than half the length of the fourth, the remaining joints each nearly equal in length to the fourth; the basal one piceo-fulvous, the rest black. Thorax twice as broad as long; sides straight, diverging from the base to beyond the middle, rounded and converging at the apex; disk impunctate, the middle disk flattened. Elytra broader than the thorax, parallel; above convex, closely and rather strongly punctured.

The metallic colour on the elytra in this species varies greatly in extent: in some specimens it covers nearly the whole surface, in others it is scarcely visible, except at the extreme base.

J. Body ovate, dilated posteriorly, strongly convex; elytra black, a curved fascia at the base, sometimes interrupted; a medial fascia and a subapical spot fulvous; these markings slightly raised above the surface of the disk.

37. Diabrotica fulvo-signata, *Baly, Ann. & Mag. Nat. Hist.* ser. 5, vol. iii. 1879, p. 77.

Hab. Colombia; also Guatemala.

The Colombian Species of the Genus *Diabrotica*, with Descriptions of those hitherto uncharacterized.—Part II.

By JOSEPH S. BALY, F.L.S.

[Read 17th December, 1885.]

SECTION II.

Second joint of antenna short, the third much longer, nearly or quite equal in length to the fourth.

Subsection 1.—Disk of thorax immaculate.

A. Body elongate or oblong, dilated posteriorly. Elytra elevate-vittate, seriate- or subseriate-punctate, the punctures being more or less regularly arranged between the vittæ in double rows; disk black or piceous, rarely (*corusca*) metallic blue or green; the entire outer limb, together with a subsutural vitta, confluent at its apex with the limb itself, flavous or yellowish white.

38. DIABROTICA CORUSCA, *v. Harold*, *Col. Hefte*, xiii. 1875, p. 92.

Hab. Magdalena River, Fusagasuga; Bogota; also Mexico, Oaxaca (*Sallé*).

Very close to *D. innuba*, Fabr.; larger and less dilated posteriorly; its elytra variable in colour, always with a distinct metallic tint.

I possess a long series of this species, the majority of them simply labelled Colombia without more precise locality.

39. DIABROTICA INNUBA, *Fabr. Syst. Ent.* 1775, p. 117.

Hab. Colombia, Magdalena River; also North America, Mexico, West-Indian Islands, and Cayenne.

Shorter and broader than *D. corusca*, v. Harold; more dilated posteriorly; in both insects the second and third costæ from the suture are equal in width, being each broader than any of the outer ones; the antennæ in both are pale and slightly stained with fuscous towards the apex, the eighth and ninth joints not being paler than the rest. This species appears to have a more extended range than the previous insect.

40. Diabrotica Kirschi. Subelongata, postice vix ampliata, nigra, nitida, antennis basi et ante apicem sordide flavis aut flavo-albidis; thorace piceo-fulvo, utrinque profunde foveolato, inter foveas depresso; elytris regulariter elevato-vittatis, vitta tertia a sutura latiori, interspatiis biseriato-punctatis; nigris aut piceis, purpureo-tinctis, margine exteriori vittaque lata subsuturali flavo-albidis; pedibus pallide flavis, genubus, tibiis, dorso tarsisque piceis. Long. $2\frac{1}{2}$ lin.

Hab. Fusagasuga; Muzo; Western Colombia (*Winkler*); Magdalena River, Bogota.

Head longer than broad, elongate-trigonate; vertex shining, impressed with very fine strigæ, visible only under a lens; front impressed with a deep fovea; clypeus sparingly clothed with griseous hairs, its surface on either side rugulose; jaws pale piceous. Antennæ filiform, the second joint short, the third and fourth equal, each twice the length of the second; four lower joints, together with the eighth and the lower portion of the ninth, obscure flavous or yellowish white. Thorax nearly twice as broad as long; sides parallel and slightly sinuate from the base to beyond the middle, thence obliquely converging towards the apex; surface sparingly impressed with very fine punctures; middle disk deeply foveolate on either side, the space between the foveæ depressed. Elytra narrowly oblong, slightly dilated posteriorly; convex, flattened along the suture; each elytron with eight narrow costate vittæ, the third from the suture broader than any of the others, their interspaces biseriate-punctate; rufo-piceous or piceous, rarely black, the outer limb and a broad subsutural vitta, which covers two or more of the longitudinal costæ, yellowish white.

Nearly allied to *D. vittata*, separated from that species by only the third costa on each elytron being broader than the rest; in *D. vittata* the second and third costæ are both broader and of equal width; in the same species all the costæ are rather wider and more strongly raised than in the present insect.

41. Diabrotica Theimei. Subelongata, postice paullo ampliata, nigra, pedibus flavis; antennis nigro-piceis aut piceis, basi fulvis, ante apicem flavo-albidis; thorace flavo-fulvo, disco postico profunde bifoveolato; elytris regulariter elevato-vittatis, vitta interna latiori, interspatiis biseriato-punctatis; nigro-piceis aut piceis, margine externo vittaque super costam internam sita, basi et apice coeuntibus, flavis. Long. $2\frac{1}{2}$–3 lin.

Hab. Sta. Martha, Bogota, also Mexico; West-India Islands, Porto Rico, Cayenne, Bahia, and Ecuador.

Head trigonate; antennæ slender, filiform, second joint very short, the third and fourth equal, each twice the length of the second, the three lower joints, together with the eighth and ninth, flavous. Thorax one half broader than long; sides nearly straight and parallel from the base to beyond the middle, thence converging towards the apex; above smooth and shining, impressed on either side behind the middle with a large deep fovea. Elytra each with about six elevated vittæ *, the one next the suture smooth and broader than the rest, their interspaces biseriate-punctate; pitchy black or piceous, the outer margin, together with a narrow vitta placed on the broad inner costa and connected at base and apex with the outer limb, pale flavous.

The sculpturing of the elytra is very similar to that of *D. Kirschi*, but the discoidal vittæ are rather more strongly developed; the ground colour of the elytra in the present species is piceous, nigro-piceous, or black, with the outer margin and a narrow raised vitta near the suture pale flavous or yellowish white. In *D. Kirschi* the subsutural vitta is much broader, covering two to four of the longitudinal costæ, so that the coloration of the elytra may be described as yellowish white with a sutural line, abbreviated near the apex, and a broad discoidal vitta (abbreviated posteriorly) nigro-piceous or piceous.

42. Diabrotica separata. Subelongata, postice paullo ampliata, nigra, nitida, capite thoraceque bifoveolatis, piceo-rufis aut sordide fulvis, antennarum articulis intermediis fuscis aut nigris, octavo quoque albidis; elytris seriato-punctatis, minus regulariter elevato-vittatis; nigris, margine externo vittaque subelevata prope suturam, basi et apice cum margine coeunti, flavo-albidis; pedibus flavis, piceo-tinctis. Long. $2\frac{1}{2}$ lin.

Hab. Eastern Colombia (*Winkler*); Magdalena River; also the Amazons (Pará and Santarem).

Head scarcely longer than broad, triangular; front impressed with a deep fovea; encarpæ trigonate; antennæ filiform, second joint short, the third more than twice its length, equal to the fourth. Thorax more than half as broad again as long; sides parallel and slightly sinuate from the base to beyond the middle, thence slightly converging to the apex; smooth and shining, deeply bifoveolate. Elytra narrowly oblong, convex, strongly

* In some specimens there are traces of two additional costæ near the suture.

punctured on the outer disk, the puncturing finer near the suture; outer disk with several distinctly raised longitudinal costæ, which commence below the humeral callus and extend nearly to the apex of the elytron, gradually becoming less distinct before their termination; the punctures between these costæ irregularly arranged in double rows; disk black, the outer half of the basal limb, the entire outer margin, together with a smooth slightly raised subsutural vitta (which corresponds to the third costa in the preceding species), connected at base and apex with the limb, yellowish white.

The pale head separates this species from *D. bivittata*, Kirsch, to which insect it is in all other characters closely allied. *D. bivittata* (which has a black head) ranges from Brazil to Ecuador; the present species, as shown above, is found in Colombia and the Amazon region. I have received numerous specimens from the latter locality, and in all the colour of the head is constant.

B. Elytra elevate-vittate, coarsely rugose-punctate between the vittæ.

43. Diabrotica coryphæa.

Diabrotica puncticollis, var., *Kirsch, Berlin. Ent. Zeit.* xxvii. 1883, p. 203.

Ovata, postice ampliata, convexa, flava, nitida; capite, antennis apice, scutello pectoreque nigris; thorace transverso, profunde bifoveolato; elytris elevato-vittatis, rude rugoso-punctatis, subopacis, nigris, margine externo (in ♂ ad apicem dilatato) flavo. Long. 3 lin.

Mas. Elytris utrisque tuberculo magno, intus excavato, ad apicem prope suturam posito, instructis.

Hab. Coper; Fusagasuga: coll. Steinheil. Magdalena River: my collection.

Head scarcely longer than broad, trigonate; vertex subrugose-punctate; clypeus granulose-punctate, its medial line with a longitudinal ridge. Antennæ slender, filiform, third joint twice the length of the second, nearly equal in length to the fourth in the male, rather shorter in the female; pale flavous, the three outer joints black. Thorax nearly twice as broad as long; sides diverging from the base to the apex, slightly sinuate behind the middle, smooth, impressed in some specimens with a few fine punctures; disk with two large deep foveæ, which are only separated by a narrow longitudinal space. Elytra oblong, gradually

dilated posteriorly; convex, disk of each elytron with five or six narrow raised vittæ, their interspaces coarsely rugose-punctate.

Closely allied to *D. viridipennis*, Jacoby, separated by the black instead of metallic green elytra; from *D. flavolimbata*, Eric. (*Balyi*, Jacoby), it may be known by the pale thorax, and by the greater number of elevated vittæ on the elytra.

44. DIABROTICA PUNCTICOLLIS, *Baly*, *Trans. Ent. Soc.* 1865, p. 346.

Hab. Ubaque: coll. Steinheil. Sta. Martha: my collection.

Similar in coloration to *D. flavolimbata*, Erich. Wiegm. Arch. 1847, p. 169; it may be known by the greater number of raised vittæ on the elytra, and by the nearly impunctate thorax.

C. Body elongate, dilated posteriorly; elytra torulose, rufous, unicolorous.

45. DIABROTICA COCCINEA, *Baly*, *Trans. Ent. Soc.* 1865, p. 345.

Hab. Muzo: coll. Steinheil. Magdalena River: my collection.

D. Body elongate, dilated posteriorly; elytra closely punctured, metallic green.

46. DIABROTICA ÆNEIPENNIS. Elongata, convexa, flavo-fulva, nitida; vertice scutelloque piceo-nigris, antennis tarsisque sordide fulvis; thorace transverso, lævi; elytris fortiter crebre punctatis, viridi-metallicis. Long. 3 lin.

Hab. La Luzula.

Head not longer than broad, triangular; antennæ filiform, the second joint short, the third and fourth nearly equal, each twice the length of the second. Thorax half as broad again as long; sides slightly rounded; disk transversely convex. Elytra oblong, sometimes slightly dilated posteriorly, coarsely and closely punctured.

E. Body subelongate or elongate, dilated posteriorly; elytra metallic blue, the entire outer limb narrowly flavous.

47. DIABROTICA FLAVO-MARGINATA. Elongata, postice vix ampliata, nigra, nitida; antennis extrorsum, femoribus thoraceque flavis, hoc transverso, disco late transversim excavato; elytris subelongatis, subparallelis, vix pone medium arcuatim excavatis, disco laterali vix pone medium excavato-sinuatis; obscure cyaneis, limbo exteriori flavo. Long. 3 lin.

Hab. Coper: coll. Steinheil. Magdalena River; Bogota: my collection.

Head much longer than broad, wedge-shaped; lower portion of front impressed with a small shallow fovea; encarpæ nearly obsolete; carina very short, linear. Antennæ filiform, the second joint very short, the third three times the length of the second rather shorter than the fourth; six lower joints black, the rest flavous. Thorax transverse; sides subparallel and sinuate from the base to just beyond the middle, thence obliquely converging towards the apex; disk smooth, rather deeply and broadly excavated. Elytra narrowly oblong, scarcely dilated posteriorly; convex, broadly and deeply excavated below the middle, and again immediately below on the outer disk; surface minutely punctured, the puncturing nearly obsolete towards the apex.

Nearly allied to *D. nigriceps*, mihi.

48. Diabrotica flavo-cincta. Subelongata, postice vix ampliata, flava, nitida; tibiis anticis dorso tarsisque infuscatis, capite nigro, antennarum articulis secundo ad quintum, undecimoque pallide piceis, penultimis duobus sordide fulvis; thorace transverso, disco transversim excavato, sulco utrinque magis profunde impresso; elytris crebre punctatis, metallico-purpureis, limbo externo flavo. Long. $2\frac{1}{2}$ lin.

Hab. Sta. Martha: my collection. Oceana (*Landoltz*): coll. Steinheil.

Head longer than broad, wedge-shaped; vertex shining, impunctate; front impressed above the encarpæ with a deep fovea; encarpæ thickened, contiguous; clypeus with a well-defined, raised, linear carina; palpi obscure fulvous; third joint of antenna twice the length of the second, distinctly shorter than the fourth. Thorax nearly twice as broad as long; sides parallel, sinuate behind the middle, slightly dilated and rounded before the latter; disk impunctate. Elytra narrowly oblong, scarcely dilated posteriorly, broadly rounded at the apex; above convex, distinctly depressed along the suture, closely and finely punctured.

F. Body oblong or subelongate, scarcely dilated posteriorly; elytra black or nigro-piceous; the outer limb, abbreviated at its extreme apex, together with a discoidal vitta or spot, flavous, the latter frequently obsolete.

49. Diabrotica similata. Subelongata, postice vix ampliata, nigra, nitida; pectore piceo, femoribus flavis, dorso nigrolineatis,

antennis piceo-nigris, apice sordide albidis; thorace rufo-flavo, disco sat profunde subarcuatim excavato; elytris extrorsum elevato-vittatis, vittis apicem versus obsoletis; interspatiis biseriato-punctatis, limbo externo, ante apicem abbreviato, vittaque discoidali, a basi fere ad apicem extensa, apice ampliata, albidis. Long. 2 lin.

Var. A. Elytris minus distincte elevato-vittatis, vitta discoidali albida obsoleta.

Hab. Magdalena River (type and var. A); Bogota (var. A).

Head scarcely longer than broad, subtrigonate; clypeus with a well-defined longitudinal ridge. Antennæ slender, filiform, the third joint twice as long as the second, equal in length to the fourth; nigro-piceous or black, the basal joint sometimes piceous; the two upper ones (the extreme apex of the terminal one excepted) obscure fulvous. Thorax half as broad again as long; sides parallel and slightly sinuate from the base to beyond the middle, thence obliquely converging to the apex; disk smooth, impressed with a deep, broad, sublunate excavation, which is rather more deeply foveolate on either side. Elytra oblong, scarcely dilated posteriorly, convex, slightly flattened along the suture; outer two thirds of each elytron elevate-costate, the inner costa broader than the others; all the costæ gradually become less defined below their middle, and entirely disappear before reaching the apex of the elytron; interspaces between the vittæ biseriate-punctate, inner disk obsoletely punctured.

50. Diabrotica incerta. Subelongata, postice vix ampliata; convexa, nigra, nitida; femoribus anticis quatuor subtus, posticisque basi, pallide flavis; thorace transverso, fulvo, disco bifoveolato, spatio inter foveas depresso; elytris oblongis, convexis, tenuiter punctatis, punctis apicem versus deletis; disco prope medium subtiliter elevato-vittatis, vittis longe ante apicem obsoletis, spatiis inter vittas magis fortiter subseriato-punctatis; cæruleo-nigris, subnitidis, limbo marginali angusto, ante apicem abbreviato, flavo. Long. 2 lin.

Hab. Bogota; Magdalena River.

Head trigonate; antennæ slender, four fifths the length of the body, entirely black. Thorax one half broader than long; sides straight and parallel from the base to beyond the middle; disk deeply bifoveolate, the space between the foveæ depressed. Elytra oblong, convex, slightly excavated on the suture at the base; minutely punctured, the punctures entirely obsolete towards the apex; on the middle disk, below the humeral callus, are five or six very fine but distinct elevated vittæ, which extend downwards for

a short distance below the middle, when they become obsolete; spaces between the vittæ rather strongly subseriate-punctate.

Closely allied to *D. similata*, the raised vittæ on the elytra much finer, the discoidal white stripe obsolete.

51. DIABROTICA PERPLEXA. Elongata, postice vix ampliata, modice convexa, nigra, nitida; antennis apice piceo-fulvis; thorace flavo, bi-foveolato; elytris obsolete elevato-vittatis, subtiliter subseriato-punctatis, punctis ad apicem deletis; limbo laterali angusto, ante apicem obsoleto, maculaque parva oblonga ante apicem, flavis; femoribus basi, tibiis anticis intus, posticisque basi, fulvis. Long. 2 lin.

Hab. Magdalena River; a single specimen.

Head longer than broad; encarpæ well defined, transverse, subquadrate; clypeus with a strongly raised longitudinal ridge; antennæ three fourths the length of the body, obsoletely thickened towards the apex, the two upper joints (the extreme apex of the terminal one excepted) piceo-fulvous. Thorax scarcely one half broader than long; sides nearly parallel from the base to some distance beyond the middle, thence slightly converging to the apex; upper surface minutely and distantly punctured, the punctures more crowded at the base: disk impressed on either side with a large shallow fovea. Elytra oblong, convex, slightly flattened along the suture, finely subseriate-punctate, the punctures entirely obsolete posteriorly; each elytron with five or six very slightly raised, ill-defined longitudinal costæ, which extend nearly the whole length of the disk; the punctures between the vittæ irregularly arranged in double rows.

The form of the thorax will separate this species from *D. mediovittata*, var. A.

52. DIABROTICA MEDIOVITTATA. Anguste oblonga, convexa, nitida, subtus nigro-picea; pedibus nigris, femoribus (dorso piceo-lineatis) tibiisque anticis intus flavis; supra nigra; antennarum articulis duobus apicalibus sordide fulvis; thorace flavo, disco profunde bifoveolato, spatio inter foveas depresso; elytris tenuiter sed distincte punctatis, punctis apicem versus fere deletis, disco externo subseriatis, utrisque limbo laterali, ante apicem abbreviato, vittaque lata a basi fere ad apicem extensa, apice interdum leviter excurvata et dilatata, flavis aut flavo-albidis. Long. $2\frac{1}{4}$ lin.

Var. A. Elytrorum vitta discoidali interrupta aut obsoleta.

Hab. Eastern Colombia (*Winkler*); Sta. Martha.

Head longer than broad, trigonate; antennæ filiform, third and fourth joints equal, each much longer than the second. Thorax

about one half broader than long; sides obliquely diverging from the base to beyond the middle, thence rounded and converging towards the apex; disk deeply bifoveolate, the space between the foveæ depressed. Elytra oblong, convex, finely and rather closely punctured, the punctures obsolete towards the apex; the outer disk rather more strongly and subseriate-punctate; in some specimens there are faint traces below the humeral callus of one or two longitudinal costæ.

53. Diabrotica abbreviata. Oblongo-ovata, convexa, fulva, nitida; tarsis antennisque, his basi exceptis, nigris, tibiis infuscatis; thorace bifoveolato; elytris lævibus, nigris, limbo laterali, vix ante apicem abbreviato, fulvo. Long. 2 lin.

Hab. Colombia (*Steinheil*).

Head not longer than broad, triangular; antennæ filiform, the second joint short, the third and fourth equal, each much longer than the second. Thorax nearly twice as broad as long; sides diverging from the base to beyond the middle, thence obliquely converging to the apex; upper surface transversely convex, hinder disk with two large, rather deeply impressed foveæ. Elytra oblong, convex, nearly impunctate; flavous limb abbreviated just before reaching the sutural angle, its extreme apex slightly dilated.

D. abbreviata may be known from *D. cinctella*, v. Harold, with which it otherwise agrees, by the absence of the longitudinal groove below the humeral callus.

54. Diabrotica cinctella, *v. Harold, Mittheil. d. Münchener ent. Ver.* 1877, p. 110.

Hab. Muzo; Mompos, El Regedor.

The specimens which I have referred to the above species have black elytra, with the outer limb (abbreviated near the sutural angle) narrowly flavous; disk very minutely and remotely punctured; on the outer disk, below the humeral callus, is a deep strongly punctured longitudinal groove, which extends for one third the length of the elytron, its inner edge subcostate.

55. Diabrotica puella. Oblonga, postice vix ampliata, convexa, nigra, nitida; femoribus flavo-albidis, abdominis disco sordide fulvo; capite (antennis exceptis) thoraceque pallide fulvis; hoc transverso, disco subarcuatim excavato; elytris convexis, disco subtiliter, ad latera magis distincte, punctatis, infra callum humeralem longitudinaliter sulcatis; limbo externo, apice extremo abbreviato, fascia arcuata

vix ante apicem posita, ad marginem adfixa, maculaque parva discoidali prope medium sita, flavo-albidis. Long. $1\frac{4}{5}$ lin.

Var. A. Elytrorum macula discoidali obsoleta.

Hab. Muzo; Medellin; Eastern Colombia (*Winkler*).

Head rather longer than broad, triangular; encarpæ thickened, contiguous; carina moderately elevated, linear; labrum and palpi nigro-piceous. Antennæ filiform, the basal joint beneath piceous; the second joint short, the third twice as long, equal in length to the fourth. Thorax more than one half as broad again as long; sides rather broadly margined, straight and slightly diverging from the base to beyond the middle, thence obliquely converging to the apex; surface shining, impunctate, middle disk with a broad transverse excavation, which is rather more deeply impressed on either side. Elytra narrowly oblong-ovate, very slightly dilated posteriorly, convex, flattened along the suture; each elytron with a deeply impressed, distinct longitudinal groove, which commences below the humeral callus and runs downwards to some little distance below the middle of the disk; this groove, which curves slightly inwards, is bounded on its outer edge by a distinctly elevated costa; the surface of the groove, together with the space between it and the outer margin, strongly punctured; rest of the disk very minutely punctured; the subapical flavous fascia is broad and placed immediately before the apex of the elytra; it is sometimes abbreviated at the extreme sutural margin.

G. Body oblong-elongate, dilated posteriorly; elytra metallic blue or green, the outer limb, together with a medial fascia, flavous; each elytron in the male with a slightly curved subapical tubercle placed near the suture.

56. Diabrotica adonis, *Baly, Ann. & Mag. Nat. Hist.* ser. 3, 1859, p. 272.

D. zonata, *v. Harold, Col. Hefte*, xiii. 1875, p. 91.

Var. A. Tibiis tarsorumque articulis basalibus duobus flavis.

Hab. Coper, Magdalena River; var. A, Muzo.

57. Diabrotica pulchra, *Baly, Trans. Ent. Soc.* 1865, p. 345.

D. gloriosa, *v. Harold, Mittheil. d. Münchener ent. Ver.* 1877, p. 110.

Hab. Fusagasuga: coll. Steinheil. Magdalena River: my collection.

H. Body subelongate, dilated posteriorly; elytra black, with fulvous markings; disk obsoletely vittate-sulcate; intermediate joints of antennæ thickened and elongate in the male sex.

58. Diabrotica Steinheili. Subelongata, postice paullo ampliata, flava, nitida; thorace, scutello femoribusque rufo-fulvis; tibiis, tarsis, metapectore capiteque nigris; antennis elongatis, piceis, articulis ultimis tribus sordide albidis; elytris tenuiter sat crebre punctatis, leviter longitudinaliter sulcatis; nigris, macula subbasali, apice lato, limbo laterali fasciaque lata prope medium, flavis. Long. $3\frac{1}{2}$ lin.

Var. A. Elytrorum macula subbasali flava obsoleta.

Var. B. Elytrorum fascia mediali flava extrorsum abbreviata.

Var. C. Elytrorum fascia obsoleta.

Mas. Antennis corpus superantibus, articulis tertio ad quintum paullo incrassatis, elongatis; sexto ad undecimum brevioribus, gracilibus; tarsorum anticorum articulo basali dilatato.

Fem. Antennis brevioribus, articulis tertio ad quintum non incrassatis.

Hab. Coper.

Head scarcely longer than broad, triangular; vertex smooth, impunctate; encarpæ transverse, contiguous; carina short, thickened, very narrowly wedge-shaped. Antennæ in the male longer than the body, the second joint short, the third more than three times its length; the third, fourth, and fifth equal in length, thickened, but each gradually decreasing in thickness from the preceding one; the third and fourth abruptly thickened at the extreme apex; the fourth and fifth slightly curved; the sixth and following joints to the apex abruptly decreased both in length and thickness, slender, filiform, each joint being about half the length of the fifth. Thorax twice as broad as long; sides bisinuate, converging beyond the middle, the hinder angles produced, acute, distinctly reflexed, the anterior ones produced, thickened, obtuse; upper surface impunctate, flattened on the hinder disk, faintly excavated transversely just in front of the basal margin. Elytra broader than the thorax, narrowly oblong, slightly dilated posteriorly, convex, faintly excavated below the basilar space, the latter obsoletely thickened; surface rather closely and distinctly punctured; each elytron with a number of shallow longitudinal sulcations, their interspaces slightly thickened.

I. Body ovate, dilated posteriorly, strongly convex; elytra subventricose, closely and coarsely punctured; very variable in coloration.

59. Diabrotica Hebe, *Baly*, *Trans. Ent. Soc.* 1865, p. 348.

Type. Nigra, nitida; vertice thoraceque trifoveolato rufo-piceis; femoribus antennisque flavis, harum articulis quinque basalibus dorso piceis; elytris castaneis, margine laterali, tertia parte postica, fasciaque vix pone medium sordide flavis.

Var. A. Elytra flava, fascia basali, alteraque vix pone medium violaceo-metallicis, cæteris ut in typo.

Var. B. Subtus flava; abdomine, tibiis tarsisque nigris; antennarum articulis basalibus quatuor dorso nigris; elytris castaneis.

Var. C. Subtus nigra, pedibus flavis; supra castanea, antennis flavis, scutello nigro.

Var. D. Nigra, elytris ut in typo, sed signaturis castaneis fere obsoletis.

Var. E. Nigra, elytris fulvis, plaga scutellari fasciaque prope medium metallico-violaceis.

Var. F. Subtus æneo-nigra, supra cum pedibus nigra; elytris flavis, fascia vix pone medium, utrinque abbreviata, metallico-purpurea.

Var. G. Nigra, abdomine æneo vix tincto; thorace nigro-piceo; elytris castaneis, utrisque ante medium fascia obsoleta fulva, linea suturali alteraque marginali, hac ante apicem abbreviata, nigris.

Var. H. Nigra, abdomine æneo tincto; elytris nigro-cæruleis.

Hab. Type and var. E, Bogota: my collection. Vars. A, B, C, and H, La Vega: coll. Steinheil. Var. D, Colombia: my collection. Var. F, Fusagasuga: coll. Steinheil. Var. G, Paine: coll. Steinheil.

J. Body subelongate, dilated posteriorly; elytra black or nigro-cyaneous, with flavous markings.

60. Diabrotica Deyrollii, *Baly*, *Trans. Ent. Soc.* 1865, p. 347.

Hab. Canaos: coll. Steinheil. Magdalena River: my collection.

In H. Steinheil's specimen the transverse band on the elytra is separated into two subovate spots; there is also a narrow and elongate additional spot, placed close to the outer margin and parallel to the subbasal patch; lastly, the abdomen is piceous at the base; in all other respects it agrees with the type.

61. Diabrotica spectanda. Subelongata, postice paullo ampliata, convexa, fulva, nitida; pectore, scutello capiteque nigris, antennis piceo-fulvis, apice flavo-albidis; thorace transversim convexo, lævi;

elytris oblongis, tenuissime punctatis, nigris; limbo laterali, macula pone basin, fascia vix pone medium, apiceque lato, flavis. Long. 2 lin.

Hab. Medellin.

Head not longer than broad, triangular; antennæ filiform; second joint short, the third more than twice as long, equal in length to the fourth. Thorax nearly one half broader than long; sides straight and parallel from the base to beyond the middle; transversely convex, the usual discoidal foveæ obsolete. Elytra oblong, convex, minutely punctured.

K. Body subelongate or narrowly oblong, dilated posteriorly; elytra flavous, with darker markings.

62. Diabrotica spiloptera. Elongato-ovata, postice vix ampliata, nigra, nitida; femoribus abdomineque flavis, tibiis tarsisque nigro-piceis; antennarum articulis nono, decimo et undecimo (hujus apice excepto) albidis; thorace subquadrato, tenuiter punctato, utrinque foveolato; elytris fulvis, utrisque maculis quinque nigris ornatis, harum prima super callum humeralem trigonata, duabus prope medium, necnon duabus inter medium et apicem, his quatuor per paria transversim positis, subrotundatis, nigris. Long. $2\frac{1}{4}$ lin.

Hab. Oceana (*Landolt*).

Front impressed with an elongate fovea; carina well defined; antennæ filiform, the second joint short, the third more than twice as long as the second, equal in length to the fourth. Thorax subquadrate; sides straight and parallel, distinctly angulate before the middle, the anterior angles thickened obtuse, the hinder ones acute; disk finely punctured, impressed on either side with a deep fovea. Elytra finely but distinctly punctured.

63. Diabrotica nigrovittulata. Anguste oblongo-ovata, postice paullo ampliata, convexa, flava, nitida; postpectore, scutello capiteque nigris; antennarum articulis 7 8que albidis; thorace transverso, disci medio obsolete excavato; elytris crebre punctatis, vittulis sex, 3 ante et 3 pone medium positis, duabus internis communibus, nigris. Long. $2\frac{2}{3}$ lin.

Hab. Colombia (*Dyson*). A single specimen in my own collection.

Head not longer than broad, triangular; antennæ with the second joint very short, the third three times as long as the preceding one, equal in length to the first, the fourth joint rather longer. Thorax twice as broad as long; sides nearly straight and parallel from the base to beyond the middle, thence converging to the apex; transversely convex, slightly

flattened and obsoletely excavated on the disk. Elytra oblong, slightly dilated towards the apex, convex, rather strongly punctured; surface with six short black vittæ, arranged transversely in two series, one placed at the base and extending nearly to the middle, the second extending from below the middle nearly to the apex, the middle vitta in each row common.

64. DIABROTICA NIGROGUTTATA. Anguste oblonga, convexa, sordide fulva; oculis scutelloque nigris, macula verticali picea; thorace quam longo distincte latiori, lævi, obsolete punctato, disco leviter subarcuatim excavato: elytris distincte subcrebre punctatis, utrisque maculis sex, duabus infra basin, duabus prope medium duabusque ante apicem, transversim dispositis, nigris. Long. 3 lin.

Hab. Nare; Mompos.

Head trigonate, not longer than broad, vertex shining, remotely punctured; third and fourth joints of antennæ nearly equal in length, each much longer than the second. Thorax broader than long; sides parallel for the greater part of their extent, sinuate from the base to beyond the middle; disk with an ill-defined sublunate excavation. Elytra oblong, slightly dilated towards the apex, moderately convex, distinctly but not closely punctured; each elytron with six black patches, arranged transversely in pairs as follows:—two below the base, the outer one covering the humeral callus, two about the middle, the outer one sublinear; and lastly, two halfway between the middle and the apex, this last pair being placed more obliquely than the previous ones.

65. DIABROTICA CIRCULATA, *v. Harold, Col. Hefte*, xiii. p. 91.

Hab. Colombia, my collection; also Guatemala and Mexico.

In the specimens before me the head is black, not nigro-æneous.

66. DIABROTICA PICEO-LINEATA. Anguste oblonga, postice paullo ampliata, flava, nitida; thorace transversim excavato, utrinque magis fortiter oblique impresso; elytris oblongis, subcrebre punctatis, vitta costata submarginali, infra humerum interrupta, apicem versus abbreviata, linea discoidali brevi, maculaque parva subscutellari communi, pallide piceis. Long. $2\frac{3}{4}$ lin.

Hab. Colombia (*Dyson*).

Head not longer than broad, subrotundate; eyes large, black; third joint of antenna more than twice as long as the second, equal in length to the fourth. Thorax about one third broader than long; sides parallel and sinuate from their base to beyond the middle, thence obliquely converging to the apex; disk broadly excavated, more deeply impressed on either side with a deep

oblique fovea. Scutellum piceo-flavous. Elytra oblong, slightly dilated posteriorly, convex, slightly depressed below the basilar space, distinctly punctured; on each is a sublateral piceous costa, which commences on the humeral callus and terminates abruptly at a short distance before reaching the apex of the elytron; the costa itself is entire, but the piceous coloration is interrupted for a short space below the humeral callus; on the middle third of the inner disk is a narrow piceous line; immediately below the scutellum is also a small pale piceous spot.

L. Body ovate, dilated posteriorly, convex; elytra closely and irregularly punctured; piceous, with flavous vittæ.

67. Diabrotica alternata. Ovata, postice paullo dilatata, convexa, nigra, nitida; pedibus flavis; genubus, scutello, ore antennisque piceis, harum articulis sexto, septimo undecimoque fuscis, octavo, nono decimoque albidis; thorace transverso, subremote punctato, disco bifoveolato, medio longitudinaliter sulcato; elytris fortiter subcrebre punctatis, punctis prope suturam subseriatim dispositis; utrisque limbo vittaque discoidali a basi fere ad apicem extensa, flavis. Long. $2\frac{3}{4}$ lin.

Hab. Magdalena River.

Head longer than broad, triangular; vertex smooth, nigro-piceous; clypeus rugose, clothed with adpressed silky hairs; antennæ filiform, the second joint short, the third nearly twice as long as the second, equal in length to the fourth. Thorax nearly twice as broad as long; sides straight and parallel from the base to beyond the middle, then converging towards the apex; apical border, together with the upper portion of the lateral margin, narrowly edged with piceous; upper surface transversely convex; disk impressed on either side with a large oblique shallow and ill-defined fovea; medial line behind the middle with a shallow longitudinal depression; surface distinctly, but rather distantly, punctured. Elytra convex, strongly punctured.

M. Elytra ovate, dilated posteriorly, strongly convex, their apices obtuse or obtusely rounded; subseriate or irregularly punctured, the hinder disk often faintly elevate-vittate; lower face in the male (in the majority of the species) deeply excavated.

68. Diabrotica beata. Ovata, postice ampliata, valde convexa, nigra, nitida; pedibus antennisque flavis, his apice nigro-piceis; thorace lævi, remote tenuiter punctato, disco utrinque fovea obliqua profunde impresso; elytris late oblongis, apicem versus paullo am-

pliatis, apice obtusis; sat valde convexis, infra basin prope suturam leviter transversim depressis, subseriatim punctatis, pone medium obsolete elevato-vittatis; nigris, fasciis duabus, una infra basin, plerumque interrupta, altera prope medium, ad marginem vix abbreviata, limboque apicali, flavis. Long. 3 lin.

Var. A. Elytrorum fascia subbasali obsoleta.

Mas. Facie inferiori non excavata; antennarum articulis, basali curvato, a paullo ante basin ad apicem incrassato, secundo brevi, compresso, tertio quam ille duplo longiori, quarto ad præcedentes duos æquilongo, leviter curvàto.

Fœm. Antennis filiformibus, articulo tertio quam quartus paullo breviori.

Hab. Santa Marta; Magdalena River; Muzo; Western Colombia (*Winkler*); Venezuela, Bogota.

Head scarcely longer than broad, subtrigonate; clypeus in either sex with an ill-defined slightly raised longitudinal ridge. Antennæ in the female slender, filiform, the third joint rather shorter than the fourth; in the male the antennæ are more robust than in the female, the first joint being curved below the middle, slender at the base, and thence thickened to the apex; the second very short, compressed and only half the length of the third; whilst the fourth, which is slightly curved, is as long as the preceding two united. Thorax one half broader than long; sides straight and parallel from the base to the middle, thence obliquely converging to the apex, the hinder angle acute; disk smooth, finely but remotely punctured, deeply impressed on either side with an oblique oblong fovea. Elytra broadly oblong, gradually dilated towards the apex, the latter obtuse, very strongly convex, transversely excavated on the suture below the basilar space; subseriate-punctate, the puncturing finer than in *D. Jekelii*; hinder disk with several ill-defined longitudinal costæ.

This species stands very close to *D. mimula*, v. Harold, an insect I only know from the author's diagnosis. The male differs in the absence of the tooth at the apex of the basal joint of the antennæ, and in the second joint of the latter being compressed and unilaterally dilated, not subglobose as stated by H. v. Harold. There is also a difference in the coloration of the elytra; the author gives the marginal limb as testaceous; in the present insect the apical limb is flavous, the lateral margin being concolorous with the disk. In all the specimens that I have seen, some twenty in number, this character is constant.

69. Diabrotica mimula, *v. Harold, Col. Hefte*, xiii. p. 92.

Hab. New Granada.

I do not know any insect which I can refer with certainty to the above species. The female of *D. Jekelii* quite agrees in coloration with v. Harold's description, but the male of that species differs entirely in possessing an excavated clypeus.

70. Diabrotica Jekelii. Ovata, postice ampliata, valde convexa, nigra; capite thoraceque flavo-fulvis, pedibus (femoribus basi exceptis) antennisque pallide flavis, his apice tarsisque infuscatis; thorace lævi, sat profunde bifoveolato; elytris late oblongis, ad apicem paullo ampliatis, apice obtusis; convexis, fortiter subseriato-punctatis, pone medium obsolete elevato-vittatis; nigris, fasciis duabus angustis, una infra basin, altera vix pone medium positis, limboque externo flavis. Long. 3 lin.

Mas. Facie inferiori profunde excavata, nigra; antennis gracilibus, articulo secundo brevi, subclavato, tertio apice oblique truncato, ad quartum fere æquilongo, articulis quarto et sequentibus obsolete carinatis.

Hab. Colombia.

Head slightly longer than broad, subtrigonate; lower portion of face in the ♂ occupied by a deep, smooth, concave excavation, which covers the upper four fifths of the clypeus; the lower face in the same sex is black; the clypeus in the ♀ is slightly convex, its medial line being faintly carinate; labrum black in both sexes; antennæ in the ♂ filiform, the third and fourth joints equal, each more than twice the length of the second. Thorax more than one half broader than long; sides straight and parallel from the base to the middle, thence obliquely converging to the apex, hinder angle acute; disk smooth, impressed on either side with a deep subrotundate fovea. Elytra broadly oblong, slightly increasing in width towards the apex, the latter obtusely rounded; upper surface strongly subseriate-punctate, irregularly wrinkled on the sides; hinder disk with a few faint traces of longitudinal costæ similar to, but much less distinct than, in *D. bella*.

Similar in coloration to *D. mimula*, v. Harold, but from that species the excavated face in the male at once separates it. The male of the present species may be known from the same sex in *D. bella* by the difference in shape of the excavated portion of the lower face. In the female of *D. Jekelii*, the third joint of the antennæ is nearly equal in length to the fourth, its apex being obliquely truncate; in *D. bella* the third is distinctly shorter than the following joint; the elytra are also less convex and less strongly costate than in the latter insect.

71. DIABROTICA JUCUNDA. Ovata, postice ampliata, valde convexa, piceo-nigra aut nigra, nitida, capite thoraceque rufo-fulvis, pedibus antennisque flavis, his extrorsum infuscatis, scutello piceo; thorace minute, remote punctato, disco utrinque oblique foveolato; elytris late oblongis, apicem versus ampliatis, apice obtusis; convexis, infra basin prope suturam leviter transversim depressis; subseriato-punctatis, flavis, utrinque puncto humerali, fascia irregulari ante medium maculaque trigonata inter medium et apicem posita, piceis. Long. 2 lin.

Mas. Facie inferiori profunde excavata; antennis filiformibus, articulo tertio quam quartus breviori.

Hab. Colombia.

Head trigonate; lower face occupied by a deep concave excavation, which covers the upper four fifths of the clypeus; antennæ filiform, the third joint distinctly shorter than the fourth. Thorax one half broader than long; sides parallel and sinuate from the base to the middle, thence obliquely converging to the apex; upper surface very finely and remotely punctured; disk impressed on either side with an oblique oblong fovea. Elytra broadly oblong, dilated towards the apex, the latter obtuse; strongly convex, slightly depressed transversely below the basilar space, subseriate-punctate; flavous, each elytron with a small spot on the humeral callus, a narrow irregular fascia just before the middle, together with a triangular patch situated between the middle and the apex, piceous.

72. DIABROTICA BELLA. Ovata, postice ampliata, valde convexa, nitida, subtus nigra, pedibus flavis; supra rufa, antennis fulvis, apice infuscatis; thorace lævi, remote et tenuiter punctato, utrinque profunde foveolato; elytris late oblongis, postice paullo ampliatis, apice obtusis; subventricosis, infra basin transversim excavatis, fortiter subseriatim punctatis, a paullo infra basin fere ad apicem distincte elevato-vittatis; rufo-piceis, fasciis duabus, una infra basin, altera vix pone medium positis, margineque apicali fulvis. Long. 3 lin.

Mas. Facie inferiori profunde transversim excavata, clypeo antico tumido; antennarum articulo secundo subclavato, tertio illo vix duplo longiori, quarto præcedentibus duobus conjunctis longiori, basi paullo curvato.

Hab. Magdalena River.

Front finely punctured, faintly rugulose; upper half of the clypeus in the ♂ deeply excavated, the lower portion of this segment thickened on the medial line; lower face in the ♀ transversely convex, coarsely punctured; antennæ in the ♂ with the

second joint subclavate, the third scarcely twice its length, and the fourth, which is very slightly curved at its base, longer than the two united; in the ♀ these organs are more slender, and the third joint is twice the length of the second, being only slightly shorter than the fourth. Thorax about one half broader than long; sides nearly parallel and slightly sinuate from the base to beyond the middle, thence obliquely converging towards the apex, the hinder angle acute; disk finely but remotely punctured, deeply bifoveolate. Elytra strongly convex, subventricose, transversely excavated below the basilar space; surface strongly subseriate-punctate, irregularly wrinkled towards the apex; each elytron with four or five longitudinal costæ, which commence below the basilar space and extend nearly to the apex.

The difference in the excavation of the face in the ♂, together with the more distinctly raised vittæ on the elytra, will separate this species from its congeners.

73. Diabrotica Stevensi.

Cerotoma Deyrollii, *Baly, Trans. Ent. Soc.* 1866, p. 477.

Hab. Colombia, Magdalena River; Venezuela, Bogota.

In the first instance I erroneously placed this species in *Cerotoma*; having subsequently discovered my mistake and ascertained that the insect belongs to the present genus, I am compelled to alter the specific name, *Deyrollei* having already been used by myself for a species (also from Colombia) described in the Transactions of the Entomological Society for 1865, p. 347.

I know three female specimens of this species; in all the third and fourth joints of the antennæ are equal in length; the male is unknown to me.

74. Diabrotica læta, *Fabr. Syst. El.* i. p. 454.

Ovata, postice ampliata, valde convexa, nigro-picea, nitida; scutello, thorace capiteque piceo-fulvis; pedibus antennisque flavis, his extrorsum nigris; thorace lævi, utrinque transversim foveolato; elytris late oblongis, postice paullo ampliatis, apice obtusis; convexis, subcrebre punctatis; nigris aut nigro-piceis, utrisque limbo externo, fascia prope medium, sutura pone fasciam, nec non maculis una vel duabus infra basin flavis. Long. $2\frac{2}{3}$ lin.

Var. A. Elytrorum vitta suturali fere ad basin extensa.

Var. B. Elytrorum vitta suturali obsoleta.

Mas. Facie inferiori late et profunde excavata; antennis filiformibus, articulo tertio quam quartus paullo breviori; articulis quarto et sequentibus intus compressis, carinatis.

Hab. Cayenne (type); vars. A and B, Colombia.

Head longer than broad, trigonate; face in the male with a large concave smooth excavation, which occupies the upper two thirds of the clypeus; antennæ in the same sex slightly more robust than in the female, the fourth and following joints slightly compressed on their inner edge, the latter obsoletely carinate; in the female the antennæ are simple, the clypeus being transversely convex, and obsoletely carinate at its base. Thorax one half broader than long; sides straight and nearly parallel from the base to the middle, thence obliquely converging towards the apex; disk smooth, impressed on either side with a shallow transverse fovea. Elytra oblong, slightly dilated towards the apex, the latter obtuse; above convex, finely but distinctly punctured.

Narrower and less convex than *D. beata*; most similar in shape to *D. clypeata*, but differing from that insect in the more slender antennæ in the male, in the finer punctuation of the elytra, and in the entirely different coloration. This species is usually placed in the genus *Cerotoma*.

75. Diabrotica clypeata. Ovata, postice paullo ampliata, valde convexa, nigra, nitida; abdomine, pedibus antennisque flavis, his apice infuscatis; thorace rufo-fulvo, leviter bifoveolato; elytris oblongis, apicem versus paullo ampliatis, apice obtusis; convexis, sat fortiter, subcrebre punctatis; flavis, utrisque maculis tribus, duabus infra basin, transversim positis, tertia ante apicem, subquadrata, fasciaque prope medium, utrinque abbreviata, nigris. Long. 3 lin.

Mas. Facie inferiori profunde et late excavata; antennarum articulo tertio quam quartus vix breviori, quarto et sequentibus intus paullo compressis, carinatis.

Hab. Colombia: my collection.

Head rather longer than broad, trigonate; whole of the lower face with a large, smooth, concave excavation, which extends upwards as far as the base of the antennæ, the latter more robust than in *D. læta*, the fourth joint distinctly longer than the third; inner edge of the fourth and following joints compressed, narrowly carinate. Thorax nearly one half broader than long; sides nearly parallel and slightly sinuate from the base to beyond the middle, thence converging towards the apex; transversely convex, disk impressed on either side with a distinct but shallow fovea. Elytra convex, rather strongly but not very closely punctured.

76. Diabrotica xanthoptera. Ovata, postice ampliata, sat valde convexa, nigra, nitida; capite thoraceque rufo-testaceis, pedibus antennisque flavis, his apice infuscatis, scutello piceo; thorace lævi, minute punctato, utrinque fovea obliqua profunde impresso; elytris late oblongis, postice ampliatis, apice obtuse rotundatis; sat valde convexis, flavis, subseriato-punctatis, punctis piceo tinctis, lineis longitudinalibus nonnullis impunctatis instructis. Long. $3\frac{1}{2}$ lin.

Mas. Facie inferiori profunde excavata, nigra.

Hab. Magdalena River.

Head longer than broad, subtrigonate; labrum piceous; antennæ slender, the third and fourth joints equal in length. Thorax one half broader than long; sides parallel and slightly sinuate from the base to the middle, thence obliquely converging towards the apex; disk smooth, very minutely and subremotely punctured, deeply depressed on either with an oblique oblong fovea. Elytra broadly oblong, dilated towards the apex, the latter obtusely rounded; above rather strongly convex, subseriate-punctate, the punctures more or less stained with piceous; inner disk with several narrow impunctate longitudinal lines. The apices of the elytra are rather less obtuse than in the other species of this subsection. The antennæ in the only male known to me are broken off.

77. Diabrotica fenestrata. Ovata, convexa, postice ampliata, sat valde convexa, nigra, nitida; capite thoraceque rufo-testaceis, pedibus antennisque flavis, scutello piceo; thorace lævi, disco utrinque foveolato, spatio inter foveas transversim depresso; elytris subseriatim punctatis, pone medium obsolete elevato-vittatis, utrisque limbo (limbo suturali pone medium obsoleto), fasciis duabus, una ante, altera vix pone medium positis, vittaque discoidali a basi ad fasciam primam extensa, flavis. Long. 3 lin.

Hab. Venezuela: a single specimen from the late Mr. W. W. Saunders's collection.

Head scarcely longer than broad; labrum and mouth black; clypeus smooth, remotely punctured, medial line with a faint longitudinal ridge; antennæ filiform, the third and fourth joints equal in length. Thorax one half as broad again as long; sides straight and parallel from the base to the middle, thence obliquely converging to the apex; disk smooth, impressed on either side with a deep subrotundate fovea, the space between the foveæ narrowly depressed. Elytra broadly oblong, dilated towards the apex, the latter obtuse; above convex, rather strongly punctured; hinder disk with several ill-defined longitudinal ridges.

Nearly allied to *D. læta*, more convex and more strongly punctured than that species; the third and fourth joints of the antennæ equal in length.

78. Diabrotica imitans, *Jacoby, Proc. Zool. Soc.* 1879, p. 791.

Hab. Venezuela.

Nearly allied to *D. clypeata*; differing (according to the author's description) in having the lower face only black, and in the interspaces on the elytra being faintly rugulose: the sculpturing of the thorax also differs; in the present species it is described as "obsoletely transversely depressed," in *D. clypeata* it is impressed on either side with a distinct fovea.

79. Diabrotica deliciosa. Anguste ovata, postice ampliata, valde convexa, nigra, nitida; pedibus flavo-fulvis, capite thoraceque rufis, hoc lævi, bifoveolato; scutello oreque piceis; elytris flavis, piceo punctatis, punctis sat fortiter impressis; utrisque maculis duabus infra basin transversim positis, plagaque magna subapicali, fere ad marginem et ad suturam extensa, nigris. (*Antennæ desunt.*) Long. 3 lin.

Hab. Colombia: a single specimen in my collection.

Head longer than broad, wedge-shaped; labrum and mouth piceous, lower face nearly plane; the antennæ (in the single specimen before me) broken off. Thorax one half broader than long; sides sinuate and slightly converging from the base to the middle, thence obliquely converging to the apex; upper surface transversely convex, disk remotely and very finely punctured, bifoveolate. Elytra oblong, gradually dilated towards the apex, the latter obtusely rounded, strongly convex, rather strongly but not very closely punctured, punctures piceous.

N. Body broadly ovate, dilated posteriorly, convex; coloration of elytra variable. Male in some species with a subapical tubercle placed near the sutural margin; the antennæ in the same sex rarely compressed and serrate.

80. Diabrotica Butleri. Ovata, postice ampliata, valde convexa, sordide flava, nitida; abdomine tarsisque nigris, metapectore, femoribus anticis basi, tibiisque obscure piceis; thorace transverso, lævi, distincte bifoveolato; elytris subventricosis, ante medium minus crebre, sat fortiter punctatis, pone medium nigris, minus nitidis, crebre et fortiter punctatis. Long. 4 lin.

Hab. S. Rosa, Manizalis: coll. Steinheil; also Medellin: my collection.

Clypeus transverse, pentangular, carina obsolete; antennæ more than three fourths the length of the body, filiform, the third joint twice the length of the second, more than three fourths the length of the fourth. Thorax scarcely one third broader than long; sides straight and parallel from the base to beyond the middle, thence obliquely converging to the apex, all the angles acute; disk smooth and shining, impressed on either side with a deep fovea. Elytra broadly ovate, enlarged posteriorly, convex, transversely depressed below the basilar space, subventricose posteriorly, the hinder half black; the anterior half rather strongly but not very closely punctured, the black hinder surface very closely and deeply punctured.

81. Diabrotica intermedia. Ovata, postice ampliata, valde convexa, flavo-picea, nitida; antennis, pedibus (femoribus exceptis) abdomineque nigris; thorace lævi, fere impunctato; elytris subcrebre punctatis, pone medium nigris, viridi tinctis, granuloso-punctatis. Long. $4\frac{1}{2}$ lin.

Hab. Colombia: my collection. Coper: coll. Steinheil.

Head longer than broad; antennæ filiform, the first and third joints equal in length, the second short, basal joint nigro-piceous. Thorax broader than long; sides parallel and faintly sinuate from the base to some distance beyond the middle, thence obliquely converging to the apex; disk transversely convex, nitidous, faintly impressed on either side with a few very minute punctures. Elytra broadly oblong, dilated posteriorly, very convex, distinctly but not very closely punctured; hinder disk black, strongly tinged with metallic green, very finely granulose-punctate, subopaque.

Broader than *D. Butleri*, hinder half of elytra less coarsely granulose-punctate.

82. Diabrotica posticata. Ovata, postice ampliata, convexa, flava, nitida; antennarum articulis intermediis nigro-piceis; abdomine elytrorumque dimidio postico nigris; thorace transverso, leviter arcuatim excavato; elytris tenuiter punctatis, punctis ad apicem fere deletis. Long. $2\frac{1}{2}$ lin.

Hab. Fusagasuga; Eastern Colombia (*Winkler*); Magdalena River.

Head much longer than broad, wedge-shaped; vertex smooth, impunctate; encarpæ trigonate, contiguous; carina linear. Antennæ filiform, the second joint half the length of the basal

one, rather more than half the length of the third, the latter scarcely shorter than the fourth; the extreme apex of the third, together with the fourth to the seventh joints, nigro-piceous. Thorax nearly twice as broad as long; sides straight and very slightly diverging from the base to beyond the middle, thence converging to the apex; above smooth, impunctate, hinder disk with a broad, shallow, subarcuate excavation. Elytra much broader than the thorax, broadly ovate, dilated towards the apex; above convex, slightly flattened along the suture, finely but distinctly punctured, the punctures nearly obsolete on the hinder disk; the hinder portion of the surface entirely covered by a large common black patch, which extends from just before the middle disk to the apex; owing to the flavous colouring extending rather lower on the sides, the anterior margin of the patch is convex.

83. Diabrotica lugubris, *Dejean, MS.* Late ovata, postice ampliata, convexa, nigra, nitida; thorace obsolete subarcuatim excavato; elytris remote punctatis, flavo-albidis, utrisque plagis magnis duabus, una ante, altera pone medium, nigris. Long. $2\frac{1}{2}$ lin.

Hab. Colombia.

Head not longer than broad; antennæ equal to the body in length, filiform, third joint nearly twice the length of the second, nearly equal to the fourth. Thorax twice as broad as long; sides parallel and nearly straight from the base to the apex, slightly sinuate behind the middle; anterior angle obliquely truncate; transversely convex, finely and somewhat irregularly but not closely punctured, hinder disk with a large, shallow, ill-defined, semilunate depression. Elytra convex, gradually dilated posteriorly, the outer limb narrowly dilated; surface subremotely punctured.

84. Diabrotica leucospila. Late ovata, postice ampliata, convexa, nigra, nitida; thorace transverso, tenuiter, remote punctato, disco evidenter arcuatim excavato; elytris late oblongis, postice ampliatis, modice convexis, sat fortiter subcrebre punctatis; limbo externo maculisque magnis quinque, duabus ad basin, tribus prope medium, harum una communi, duabusque apicalibus albidis. Long. 2 lin.

Mas. Elytris singulis callo subconico, ante apicem juxta suturam posito, instructis.

Hab. Magdalena River.

Head scarcely longer than broad. Antennæ nearly three

fourths the length of the body, robust, filiform, slightly thickened towards the apex; second joint short, subovate, third and fourth equal, each nearly twice the length of the second. Thorax nearly twice as broad as long; sides straight and parallel, slightly converging at the apex; upper surface transversely convex, disk with a shallow sublunate excavation, ill-defined on the medial line, but more distinct on either side. Elytra subquadrate-ovate, slightly dilated posteriorly, moderately convex, obsoletely depressed below the basilar space; strongly punctured, the interspaces minutely punctate; the outer limb and five large patches on the disk white. These patches are arranged as follows:—two at the base, one on each elytron, covering the humeral callus, and extending to the outer margin; three across the middle, the middle one common, the others lateral and attached to the outer limb; lastly two, larger than the others, placed one at the apex of each elytron.

85. Diabrotica tetraspilota. Late ovata, postice ampliata, convexa, nigra, nitida; thorace pallide flavo, late subarcuatim excavato, utrinque magis fortiter impresso; elytris subcrebre punctatis, punctis apicem versus fere deletis; flavo-albidis, utrisque plagis magnis duabus nigris, prima subrotundata, a basi ad tertiam partem elytri extensa, secunda subquadrata, vix pone medium posita. Long. $2\frac{1}{2}$ lin.

Mas. Elytris utrisque callis duobus, ante apicem oblique positis, primo valido, subconico, prope suturam, secundo parvo, paullo elevato, prope marginem externum.

Hab. Fusagasuga: coll. Steinheil. Colombia: my collection.

Head triangular; vertex smooth, impunctate; front impressed above the encarpæ with a deep fovea; encarpæ thickened, transversely trigonate, shining black; carina distinct, linear; antennæ in the male equal to the body in length, filiform, the second joint ovate, two thirds the length of the third, the latter three fourths the length of the fourth. Thorax nearly twice as broad as long; sides straight and parallel from the base to the middle, slightly dilated and rounded before the latter; disk shining, impunctate, its middle broadly excavated, the excavation more deeply impressed on either side, its anterior margin straight, its hinder one arcuate. Elytra much broader than the thorax, dilated posteriorly, each rounded at the apex, the sutural angle very obtuse; above convex, rather closely and distinctly punctured, the puncturing much finer below the middle, nearly obsolete at the apex.

86. Diabrotica propinqua. Late ovata, postice ampliata, convexa, nigra, nitida; pedibus abdomineque piceo-fulvis; thorace transverso, granuloso, subcrebre punctato, late sed leviter arcuatim excavato; elytris subcrebre punctatis, utrisque plagis magnis duabus, una infra basin, altera pone medium, nigris. Long. 2 lin.

Hab. Sta. Martha.

Head not longer than broad, trigonate; clypeus with a strongly raised longitudinal ridge; antennæ with the third joint slightly longer than the fourth, the second joint short, the first to the seventh piceous, the eighth pale piceo-fulvous, the rest wanting. Thorax more than twice as broad as long; sides obliquely diverging from the base to beyond the middle, thence rounded and converging to the apex; upper surface transversely convex, granulose, finely but distinctly punctured; disk with a broad shallow semilunate excavation; lateral margin broad, reflexed. Elytra dilated towards the apex, the latter broadly rounded; convex, distinctly but not closely punctured, their interspaces minutely punctate; each elytron with two large black patches, the first subquadrate, placed below the base, the second rather less regular in shape, halfway between the middle and the apex.

87. Diabrotica robusta. Late ovata, postice ampliata, convexa, flava, nitida; antennis, articulo basali excepto, femoribus dorso, tibiis tarsisque nigris; thorace lævi, transversim subarcuatim sulcato; elytris convexis, subremote punctatis, utrisque maculis tribus, duabus infra basin transversim positis, tertiaque vix pone medium, subrotundata, nigris. Long. 2½ lin.

Hab. Muzo; Sta. Martha; Magdalena River; Bogota.

Head longer than broad, subcuneiform; clypeus with a longitudinal ridge; antennæ filiform, third and fourth joints equal, each twice the length of the second. Thorax twice as broad as long; sides parallel, slightly dilated and convex before the middle; transversely convex; hinder disk with an ill-defined semilunate excavation, which is rather more depressed on either side. Elytra convex, dilated posteriorly, narrowly depressed along the suture at the base, outer limb narrowly dilated; surface finely but not closely punctured.

88. Diabrotica serraticornis. Late ovata, postice paullo ampliata, convexa, flavo-albida, nitida; tibiis, basi excepta, tarsisque piceis; scutello, ore oculisque nigris; antennis leviter infuscatis; thorace transverso, lævi, pone medium leviter transversim excavato; elytris

tenuiter punctatis, utrisque plaga infra basin alteraque pone medium, nigris. Long. $2\frac{1}{4}$ lin.

Mas. Antennarum articulis tertio ad sextum difformibus.

Hab. Magdalena River: my collection. Eastern Colombia (*Winkler*): coll. Steinheil.

Head not longer than broad, triangular, front with a longitudinal groove; clypeus with a faint longitudinal ridge. Antennæ with the second joint short, submoniliform, the third to the sixth thickened, the third equal in length to the first, clavate, its apex obliquely truncate, the fourth and fifth shorter, trigonate, equal, the sixth nearly equal in length to the third, clavate. Thorax twice as broad as long; sides slightly rounded, obliquely diverging from the base to the middle; transversely convex, slightly flattened on the disk; hinder disk with a shallow ill-defined transverse excavation. Elytra much broader than the thorax, convex, the outer limb narrowly dilated; surface finely but not closely punctured.

This species in general form closely resembles *D. robusta*.

89. Diabrotica insignita. Late ovata, postice paullo ampliata, convexa, nigra, nitida; thorace transverso, lævi, utrinque leviter foveolato, rufo-testaceo; antennis apice elytrisque flavo-albidis; his tenuiter punctatis, fasciis duabus, prima a basi ad quartam partem elytri longitudinis extensa, altera vix pone medium, extrorsum abbreviata, nigris, ornatis. Long. 2 lin.

Hab. Muzo; Medellin, Eastern Colombia (*Winkler*).

Head longer than broad, wedge-shaped; vertex shining, impunctate; encarpæ thickened, contiguous; carina raised, linear, well defined; antennæ filiform, the third joint nearly twice the length of the second, four fifths the length of the fourth, the ninth and tenth, together with the lower half of the eleventh, obscure white, the rest black. Thorax more than half as broad again as long; sides straight and parallel from the base to beyond the middle, thence converging to the apex; disk smooth, impressed on either side with a large and shallow fovea; at the base, just in front of the scutellum, is a third, much smaller than the others. Elytra broader than the thorax, oblong-ovate, slightly dilated towards the apex; convex, finely but not very closely punctured.

Subsection 2. Thorax pale with dark markings.

90. Diabrotica Chevrolati, *v. Harold, Coleopt. Hefte*, xiii. 1875, p. 93.

Var. A. Elytris pone medium fere totis fulvis.

Hab. Magdalena River, also Ecuador: my collection. Mexico (*Von Harold*).

91. Diabrotica sexplagiata, *Jacoby, Proc. Zool. Soc. Lond.* 1878, p. 151.

Hab. Muzo: coll. Steinheil. Sta. Martha; Magdalena River: coll. Baly.

92. Diabrotica bivittaticollis. Elongata, convexa, flava, nitida; antennis extrorsum, femoribus posticis dorso, tibiis tarsisque posticis quatuor nigris; tibiis anticis dorso, tarsis anticis antennisque basi piceis; thorace transverso, disco profunde subarcuatim excavato, utrinque ad latus vitta lata, basi et apice abbreviata, nigra ornato; elytris rugulosis, fortiter punctatis, nigris, utrisque limbo externo, maculisque magnis tribus, una infra basis, secunda prope medium tertiaque inter medium et apicem positis, flavis. Long. 2 lin.

Hab. Magdalena River.

Head slightly longer than broad; antennæ slender, filiform, the second joint short, third and fourth nearly equal, each twice the length of the second; five lower joints piceous, the rest black. Thorax broader than long; sides straight and parallel from the base to just beyond the middle, thence obliquely converging to the apex; disk impressed with a deep semilunate excavation, which is rather more deeply excavated on either side. Elytra narrowly oblong, convex, rugulose, coarsely and deeply punctured.

93. Diabrotica lætabilis. Elongata, convexa, pallide flava, nitida; abdomine, scutello antennisque nigris, his basi piceis; vertice elytrisque læte metallico-viridibus; thorace transverso, late transversim excavato, utrinque prope marginem plaga nigro-picea ornato; elytris leviter rugulosis, minus crebre punctatis, infra callum humeralem elevato-bivittatis. Long. $1\frac{1}{2}$ lin.

Hab. Magdalena River, Bogota.

Head not longer that broad, subrotundate; labrum nigro-piceous; vertex longitudinally grooved. Antennæ slender, filiform, second joint short, the third and fourth each much longer than the second, equal; four lower joints piceous, the rest black. Thorax more than half as long again as broad; sides parallel and sinuate from the base to beyond the middle, thence obliquely converging to the apex; disk broadly and transversely excavated. Elytra narrowly oblong, convex, faintly excavated below the basilar space, the latter slightly elevated; outer disk below the

humeral callus with two longitudinal costæ, which terminate at a short distance below the middle of the elytron; surface strongly but not closely punctured, irregularly wrinkled.

Similar in form to *D. bivittaticollis*; smaller, the thorax less deeply excavated; the elytra much less closely punctured.

APPENDIX.

Spec. 7 a. DIABROTICA KLUGII. Oblonga, postice ampliata, convexa, flava, nitida; capite, scutello, pectore, tibiis tarsisque nigris; thorace antennisque piceis, harum articulis penultimis duobus sordidi-albidis, thorace lævi, utrinque obsolete foveolato; elytris minute punctatis, maculis undecim, tribus basalibus, quatuor ante, et quatuor pone medium, transversim dispositis, nigro-cæruleis ornatis. Long. $2\frac{1}{2}$ lin.

Hab. Colombia, Magdalena River.

Antennæ piceous, in some specimens pale fuscous, second and third joints short, equal, the third equal in length to the preceding two. Thorax smooth, impunctate; disk impressed on either side with a small fovea. Markings on elytra disposed as in *D. spilota*, the outer one of the third row is sometimes obsolete. The black tibiæ and tarsi, together with the foveæ on the thorax, will separate this species from *D. spilota*.

DIABROTICA FUSCO-MACULATA, *Jacoby*, *Proc. Zool. Soc.* 1878, p. 994 = D. ornatula, *mihi*, *anteà*, p. 224.

Subsequently to the first part of this paper being in print, I discovered that the above insect had been previously described by Mr. Jacoby; my name must therefore fall. Mr. Jacoby gives Ecuador and Bogota as localities of the species.

Species unknown to me:—

DIABROTICA INSTABILIS, *v. Harold*, *Mittheil. d. Münchener Ent. Ver.* 1877, p. 111.

"Vertice medio foveolato, thorace evidenter bifoveolato, elytris subnitidis, sat dense punctatis; corpore subtus cum pedibus, metasterno nigro excepto, testaceo, supra vel omnino testaceo vel vario modo nigro-signato. Long. 5 mill.

"Colombia.

"Var. *a*. Supra omnino testacea, antennarum articulis 6–8 subinfuscatis.

"Var. *b*. Elytris vitta humerali alterisque utrinque duabus ante medium et post medium, transversim positis, nigris.

"Var. *c*. Elytris vitta humerali, puncto ante medium alteroque ante apicem, præterea macula oblonga ad marginem ante apicem, nigris.

"Var. *d.* Elytris vitta marginali, sutura ad basin maculaque ante apicem nigris.

"Var. *e.* Elytris ad suturam, macula humerali et signatura sublaterali, formam fere literæ X exhibente, nigris.

"Prope accedit ad *D. abruptam*, præcipue var. *d*, et thorace breviori et sat fortiter bifoveolato, foveolis transversim inter se subconfluentibus, diversa."

DIABROTICA LACORDAIREI, *Kirsch*, *Berl. ent. Zeitsch.* xxvii. 1883, Heft ii. p. 199.

"Oblonga, convexa, supra glabra, subtus pubescens, albida; capite, antennis, elytris et metasterno nigris, antennarum articulis duobus antepenultimis et basi ultimi albis; elytris sparse punctatis, maculis quatuor (2, 1, 1, intermedia maxima transversa) eburneis; pedibus nigris, femorum basi albida. Long. 9–10, lat. $4\frac{1}{2}$ mill."

"Patria Bogotá.

DIABROTICA JACOBYI, *Kirsch*, *l. c.* p. 200.

"Oblonga, nitida, glabra, nigra; antennarum articulis duobus penultimis albidis, femoribus posticis abdomineque testaceis, prothorace, mesosterno, femoribus anterioribus elytrisque prasinis, his apice sulfureis, basi fusco bimaculatis. Long. 6, lat. $2\frac{1}{2}$ mill."

"Patria Nova Granada (Itinere Popayan-Huilda, 1800–2500 M. alt.)."

Owing to the author not having given the relative lengths of the second and third joints of the antennæ, I am unable to place these species in either of the two sections into which I have divided the insects described or enumerated in this paper. *D. Jacobyi* is probably a variety of *D. fusco-maculata*, Jacoby.

Description of *Strongylus Axei* (Cobb.), preceded by Remarks on its Affinities. By T. SPENCER COBBOLD, M.D., F.R.S., F.L.S., Hon. Vice-Pres. Birmingham Nat. Hist. and Microscopical Society.

[Read 21st January, 1886.]

(PLATE XXXII.)

EIGHT years back the late Principal of the Royal Veterinary College, Professor J. B. Simonds, called my attention to a pen-and-ink sketch of a very small parasitic Nematoid. The figure (reproduced below) was accompanied by a MS. note stating that the entozoon was one of several "embryonic worms" found by a student in the mucous membrane of the stomach of a donkey. The

original find was made in November 1864, the student-discoverer being the present well-known authority on comparative pathology, Professor Axe. The sketch itself afforded no indication as to the size of the worm; but it was alleged that the parasites were barely visible to the naked eye, and further that similar microscopic Entozoa had since been procured from the stomach-walls of three more donkeys. Being invited to pronounce offhand upon their nature, I at once remarked that the enlargement at the tail-end, surmounted as it was by a dark line suggestive of the presence of spicules, implied that these so-called "embryonic worms" must be adult male Nematoids. I also added, "The worms are new to science." Further, without waiting for verification, I named the parasite in honour of its discoverer, and published a brief notice of the find in my general treatise ('Parasites,' 1879, p. 383). Subsequently a short description of the parasite appeared in the pages of a professional periodical ('The Veterinarian,' Jan. 1884, p. 6).


Copy of Simond's original drawing.

Priority of discovery in Professor Axe's favour having been thus secured, I have since sought and obtained abundant opportunity of verifying and extending the scanty facts on which the original diagnosis was founded. When occupying the chair of Helminthology at the college, students repeatedly brought me fresh specimens from dissecting-room subjects, the most successful pupil being Mr. Hassell. Apart, however, from all questions of personal interest attaching to its discovery, the parasite is of particular importance not only on account of its small size, but also in respect of its affinity with other gastric and intestinal strongyles. No figure of it has hitherto been published. Its structural characters correspond very closely with those which I described as marking the little entozoon infesting the proventriculus of ostriches (*Strongylus Douglassii*, Cobb.), and, so far as I know, these two species are the smallest of their genus. Then, again, its manifest affinity with the grouse strongyle (*Str. pergracilis*, Cobb.) and with the stomach-worm of lambs (*Str. contortus*) is noteworthy. Quite a variety of maw-worms have recently been discovered; and although there is at present no evidence to prove that donkeys actually suffer from the

presence of maw-worms, yet it is quite certain that other animals do suffer, not excluding the ass's congener, the horse, which not unfrequently develops gastric growths due to *Spiroptera megastoma*. In one case rupture and death ensued.

Apart from all practical considerations, the new parasite from the ass helps to throw light upon questions of morphology. In this connection it may be permitted me to add that the singular maw-worm described by me from the hog (*Simondsia paradoxa*, Cobb.) is by far the most remarkable nematode infesting vertebrates. Since my paper appeared in the Society's 'Transactions' (2nd ser. Zool. vol. ii. part 8) Professor Schneider has, at my request, been good enough to examine two examples, male and female. Whilst correcting me in some particulars of detail, he appears to think that I have even underrated the value and significance of the find both in its morphological and zoological aspects. His conception of a possible rhizocephalous relation, however, would be more readily convincing if there were in *Simondsia* any signs of retrograde metamorphosis, apart from the existence of a large protective "rosette" or sac-covering of the uterine tubes, which, as in *Sacculina*, acts as an organ of anchorage *.

* Prof. Schneider, in a letter to me, says:—"The male *Simondsia* possesses two unequal spicula and four pre-anal papillæ. Accordingly the *Simondsia* would belong to the genus *Filaria*, in my system of Nematoda; and according to Rudolphi's system, to *Spiroptera*. It seems to me, however, to be different from *Spiroptera strongylina*, Rud. (*Filaria strongylina*, mihi), and that it cannot be looked upon in the light of a developmental condition of *Filaria strongylina*.

"The remarkable sac-like protrusion contains (as you have discovered and as I have convinced myself) the chief mass of the sexual organs and an extension of the intestine. I venture, however, to remark that I do not believe the protrusion to be an inversion of the uterus, as it proceeds directly from the skin. It is an outgrowth from the integument, for one can plainly see that the diagonal lines of the skin, which are always present in Nematodes, also pass on to the protrusion (Ausbuchtung), the passage of the body-skin on to the protrusion being everywhere a gradual one. According to my interpretation the vulva lies not in the protrusion itself, but in front of the same. Yet I dare not affirm this with certainty, on account of the difficulty of examining a single example which has been so long preserved.

"The *Simondsia* would thus not connect itself with *Sphærularia*, but would serve to demonstrate a hitherto unknown and very remarkable modification of the Nematode-body. The importance of your beautiful discovery would be thereby only increased. According to my belief, *Simondsia* exhibits in the embryo and larval condition, and probably also at first in the sexually mature

The following characters distinguish the microscopic maw-worm of the ass :—

STRONGYLUS AXEI (*Cobb.*):

Body filiform, narrowed in front and behind; *mouth* simple, with short œsophagus and strong chitin layer; *hood* bilobed, with deeply cleft anterior ray and widely separated divisions; trunk of the posterior ray united to its fellow, bifurcate at the end: spicules three, the two larger nearly equal, with a small third or accessory piece intercalated; *tail* of female ending in a post-anal cone, finely pointed; *vulva* within the lower sixth of the body. Length of male nearly $\frac{1}{6}''$ (strictly $\frac{15}{100}$ in.); of female $\frac{1}{5}''$ ($\frac{20}{100}$ in.).

Hab. Mucous membrane of the stomach of the ass (*Equus asinus*).

Whilst the extreme transparency of the worm readily permits the ova and other organs to be measured *in situ*, the tubal and ovarian filaments, as well as the corresponding elements in the male, entirely escape observation. The lumen of the œsophagus is clearly traceable, a dark line below it representing the closed pharynx; but I could find no trace of any bulb or other line of separation between the pharynx and the chylous intestine. I suspect the arrangement is the same as obtains in *Strongylus Douglassii*. The mid gut is well marked, as is also the rectum at its anal end.

The pattern of the hood is distinctive, well pronounced, and symmetrical. The widely separated divisions of the anterior ray are thumb-and-finger-like, the upper digitoid being comparatively short and narrow, whilst the lower is closely applied to the succeeding ray, except at the end which is turned upward. The antero-lateral or second ray is paramount and directed downward. The middle, third or lateral, ray proper is of moderate size and deeply cleft into equal halves. The postero-lateral or fourth ray is narrow, straight, and placed well apart. The posterior or fifth ray is narrower, and has the shaft united to its fellow of the

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state, the usual nematode form. During its residence in the gastric glands the body-skin grows out, forming the great and the small protrusions which grow into the stomach-glands and serve for the imbibition of nourishment. The relation [thus established] reminds one of the Rhizocephala among the Crustacea."—(Signed) A. SCHNEIDER, Breslau, Oct. 13, 1885.

opposite lobe throughout its upper two thirds, the lower end bifurcating into subequal divisions. If the ray pattern as a whole be compared with that seen in the ostrich strongyle, the affinity of the two species becomes apparent. The general form and disposition of the rays are similar throughout, the most striking difference being that of the cleavage of the posterior ray, which in *Strongylus Douglassii* is three-cleft. It is interesting to observe that whilst all the rays in the ostrich strongyle are relatively stouter than they are in *Strongylus Axei*, they nevertheless individually bear towards each other similar proportions in both species *. Thus the thumb-and-finger-like form of the anterior, the paramount antero-lateral, the moderate-sized middle, the isolated postero-lateral, and the slender posterior rays of *S. Axei* have their counterpart, ray for ray, in *S. Douglassii*. Nevertheless the distinctions already noticed have full specific value apart from those affecting other organs. Quite recently another and larger species of Strongyloid worm (*Sclerostoma struthionis*) has been discovered by Dr. Horst in an Ostrich (*Struthio molybdophanes*). In Horst's entozoon the ray-pattern is altogether unlike either of the above-named species †.

The eggs of *Strongylus Axei* are relatively large, and one can clearly observe the process of yolk-segmentation through the finely-striated integument of the body-wall. The large and conspicuous spicules are ploughshare-shaped, with a tendency towards division of the shaft, the intercalated small spicule being simple and slightly winged at the centre. This accessory piece can only be seen by strongly pressing the cover-glass, or by dissection. In the ostrich strongyle I did not find a third spicule; but I infer that it is present from the general correspondence of the larger organs in both species.

The facts above stated will perhaps be further emphasized by the accompanying approximate measurements :—Head $\frac{1}{1000}''$ to $\frac{1}{750}''$ broad; tail, above the spicules $\frac{1}{250}''$, at the narrowest part above the anus of the female $\frac{1}{680}''$; base of the tail-cone $\frac{1}{1000}''$ in breadth, length $\frac{1}{350}''$; hood $\frac{1}{200}''$ in length by $\frac{1}{80}''$ in breadth; large spicules $\frac{1}{240}''$ and $\frac{1}{230}''$ respectively, accessory piece $\frac{1}{450}''$ in length; eggs $\frac{1}{250}''$ to $\frac{1}{225}''$ in length by an average of $\frac{1}{400}''$ in breadth; distance from the anus to the vulva $\frac{1}{33}''$.

* Journ. Linn. Soc., Zoology, vol. xvi. plate iv. fig. 3.

† Notes from the Leyden Museum, vol. vii. p. 263.

DESCRIPTION OF PLATE XXXII.

Figs. 1 & 2. Male and female *Strongylus Axei.* × 25 diameters.
Fig. 3. Side view of the tail of the male. × 65 diam.
Fig. 4. Front view of the same. × 85 diam.
Fig. 5. Side view of the lower end of the body of the female. × 65 diam.
Figs. 6, 7, & 8. Head, portion of the body, and tail of the female. × 265 diam.
Fig. 9. Tail and hood of the male. × 355 diam.
Fig. 10. Plan of the hood, with its lobes and rays expanded. × 225 diam.

a, head, and *a**, mouth; *b*, chitin-lines and lumen; *c*, closed œsophagus; *d*, muscular wall of same; *e*, *e*, chylous intestine or mid gut; *f*, rectum; *g*, anus; *h*, vulva; *i*, upper, and *j*, lower horn of uterus; *k*, *k*, ova; *k**, chitinous shell; *l*, *l*, cleavage-lines of yolk, and *l**, *l**, nuclei of cells; *m*, tail-cone of female; *n*, *n**, right and left spicules; *o*, accessory piece; *p*, *p**, right and left hood-lobes; *q*, *q'*, upper and lower divisions of anterior ray; *r*, antero-lateral ray; *s*, *s**, upper and lower divisions of middle ray; *t*, postero-lateral ray; *u*, bifurcate extremity, and *u**, trunk of posterior ray; *v*, *v*, transverse striæ of integument.

Note.—All figures were outlined with the aid of a camera; the upper end of fig. 8 being a little out of focus, is a trifle too broad at that part.—T. S. C.

On *Slavina* and *Ophidonais*. By Edward C. Bousfield, L.R.C.P. Lond. (Communicated by Dr. J. Murie, F.L.S.)

[Read 4th February, 1886.]

(Plate XXXIII.)

The recently published 'System und Morphologie der Oligochæten' of Vejdovsky contains many names new to science among the genera and species therein described; and among them the genus *Slavina*, formed to include the *Nais appendiculata* of D'Udekem, and, as identical with it, the *Nais lurida* of Timm. Succinct and clear description of species, adequate for identification, can hardly be said to be the strong point of Vejdovsky's work—possibly he is reserving it for the promised second part; but as in the case of *Slavina* the description is more clear than usual, and several figures are given, there can be little doubt, as I hope to show, that his *Slavina appendiculata* is identical with the species described by D'Udekem, but widely different from that described by Timm.

The species described by Vejdovsky has not come under my notice; but of the *Nais lurida* of Timm I have had many speci-

S. ONGYLUS AXEI. Coll.

mens sent me from Oxfordshire and Wiltshire, and also by Mr. Bolton of Birmingham, the well-known dealer in natural-history objects.

The body is composed of 30 to 35 segments; the head rounded and thickly studded with sharp palpocils or tactile hairs; the integument thick and somewhat opaque, and the more so on account of the case, composed of organic débris, agglutinated by the secretion of the skin, in which it is usually enclosed. Through this case protrude the setæ and the peculiar papilliform appendages which are characteristic of the genus. The setæ of the ventral bristle-bundles are long and strong, curved like the old-fashioned long ſ, with a shoulder at the junction of the outer third with the rest of the shaft, somewhat tapered off at the inner extremity, and with the outer end divided into two nearly equal teeth. It is worthy of remark that in these, as in many other Oligochæta, the teeth point backwards in the anterior segments, and forwards in the posterior; so that the worm possesses the power of resisting traction at either end, and of moving freely backward or forward. In the middle segments the teeth appear to be directed outward from the middle line.

The dorsal setæ are long and strong, usually straight, or nearly so. The first pair of bundles contain each one very long seta with a short hooked one (somewhat resembling the ventral setæ, but with the shoulder nearer the outer extremity). There may be a second capillary seta; but if so, it is usually not more than half the length of the primary one. The setæ of the remaining dorsal bundles are of the same length as the shorter one in the first pair; and all are usually straight, or nearly so.

The touch-organs (*Sinneshügel*) are elevations of the integument from which protrude several short palpocils, which, as shown in the drawing (fig. 4), are connected with special cells in the epidermis. Similar cells, in connexion with tactile hairs, occur in *Chætogaster*, where, after the use of weak osmic acid, I have been able to trace the nerve-fibre from the inner end, though without being able to make out its connexion with the general nervous system. As, however, I have seen multipolar ganglion-cells on the inner surface of the integument, there is doubtless a connexion between them and the nerve-fibres of the palpocils.

The touch-organs are arranged in rings on all the segments, rather more numerously on the first, though I have seen nothing

like the serrated margin shown in Vejdovsky's figure, reproduced in the drawing (fig. 3). As a rule, there is one ring round each of the first four bristle-bearing segments and two round each of the following, the one corresponding (as in the first form) with the position of the setæ, the second round the middle of the segment. The tail, like the head, is provided with a greater number somewhat irregularly disposed. These organs are usually wanting on the under surface, and each ring is composed of from six to eight.

The eyes are purple; the corpuscles of the perivisceral fluid oval, hyaline, showing no trace of granules, and very abundant.

These characters will, I think, suffice for the identification of the species; I pass, therefore, to show the differences between it and the *Nais appendiculata* of D'Udekem, to include which the genus *Slavina* was founded.

In this species the first pair of bristle-bundles on the dorsal aspect consist of two or three long fine bristles in each, with one or two shorter ones, so that there may be as many as from three to five in each; whilst the succeeding bundles each contain two or more short bristles, not exceeding in length the transverse diameter of their possessor, or but little exceeding it, being, according to Vejdovsky's account, so fine that it might be thought almost that they were absent.

The touch-organs are arranged in a single row round each segment, are much more numerous, as many as twenty in each ring, and are found on the under surface as well.

The eyes are brownish black; the number of segments and the character of the corpuscles of the perivisceral fluid are similar to those of the *Nais lurida* of Timm.

Whilst engaged in studying the characters of these worms, I received from Mr. Bolton several specimens of a worm which I was at first inclined to regard as a new species, which also possessed the touch-organs already described; but on further consideration I am inclined to refer it to the *Ophidonais serpentina* of Gervais, *Nais serpentina* of some other writers.

In the possession of a case formed of débris and mucous secretion, presence of touch-organs, and arrangement of alimentary canal, however, this species comes so near Vejdovsky's *Slavina*, that had he observed the touch-organs, he would probably either not have founded his new genus, or have done away with the genus *Ophidonais*.

The latter differs from other species of *Slavina* in the arrangement of the dorsal bristles and in its greater size.

The dorsal bristles are often wanting altogether in many of the segments; about the middle of the worm they are generally arranged, for the space of a few segments, with some approach to regularity; but in the anterior and posterior portions only an isolated segment here and there bears one, frequently unpaired. There is only one bristle in each bundle when present, a short straight bristle, slightly toothed at its outer extremity, which does little more than just appear through the integument, with a shoulder at about the junction of the outer fourth with the rest of the shaft.

The touch-organs are irregularly disposed, but usually more or less in rings, very numerous on the head, as shown in the drawing (fig. 5), less so on the body, whilst toward the posterior part they are often arranged almost in the same manner as in *Slavina lurida*. The eyes are blackish-brown, and the corpuscles of the perivisceral fluid spherical and granular. There are usually four streaks of greenish-brown pigmentary matter on the first five segments.

The above characters on the whole, I venture to think, justify the incorporation of this annelid with the genus *Slavina*; the reasons for this course rather than the converse one of transferring the species of *Slavina* to the genus *Ophidonais*, being that the arrangement suggested by Gervais has met with but small favour; and that as his genus *Ophidonais* includes but the one species, it seems preferable to do away with that rather than with the one proposed by Vejdovsky in the work which, after all, must at present be regarded as the standard of reference, containing, as it does, the only attempt which has hitherto been made to give a complete account of the Oligochæta as a whole.

I propose, therefore (retaining the specific names), to call the worm which I have last described *Slavina serpentina*, and the former one *Slavina lurida*, the following being a short *résumé* of the genus.

Family NAIDOMORPHA, *Vejdovsky*.

Genus SLAVINA, *Vejdovsky*.

Annelids provided with papilliform elevations of the cutis (touch-organs) usually arranged in rings; inhabiting cases formed of débris agglutinated by a mucous secretion from the bodies of the bearers.

Slavina appendiculata (*Vejdovsky*).
Nais appendiculata, *D'Udekem.*

Segments 30–40. The dorsal bristles, except the first pair, short and fine, more than two in each bundle; the first pair very long, each composed of three or more long setæ. Corpuscles of perivisceral fluid oval and hyaline. One ring of touch-organs on each segment.

Slavina lurida.
Nais lurida, *Timm.*

Segments 30–40. The first pair of dorsal bristles long and stout, not more than one long one in each bundle, sometimes a second of half the length, which is also the length of the succeeding ones, and of which there are not more than two in each bundle. The touch-organs usually in two rings on each segment. Perivisceral corpuscles oval and hyaline.

Slavina serpentina.
Ophidonais serpentina (*Gervais*).

Segments 70–80. Dorsal bristles short and straight, frequently wanting. Touch-organs irregularly arranged on anterior segments, on posterior usually as in *S. lurida.* Perivisceral corpuscles spherical and granular. Usually four pigment-bands on first five segments.

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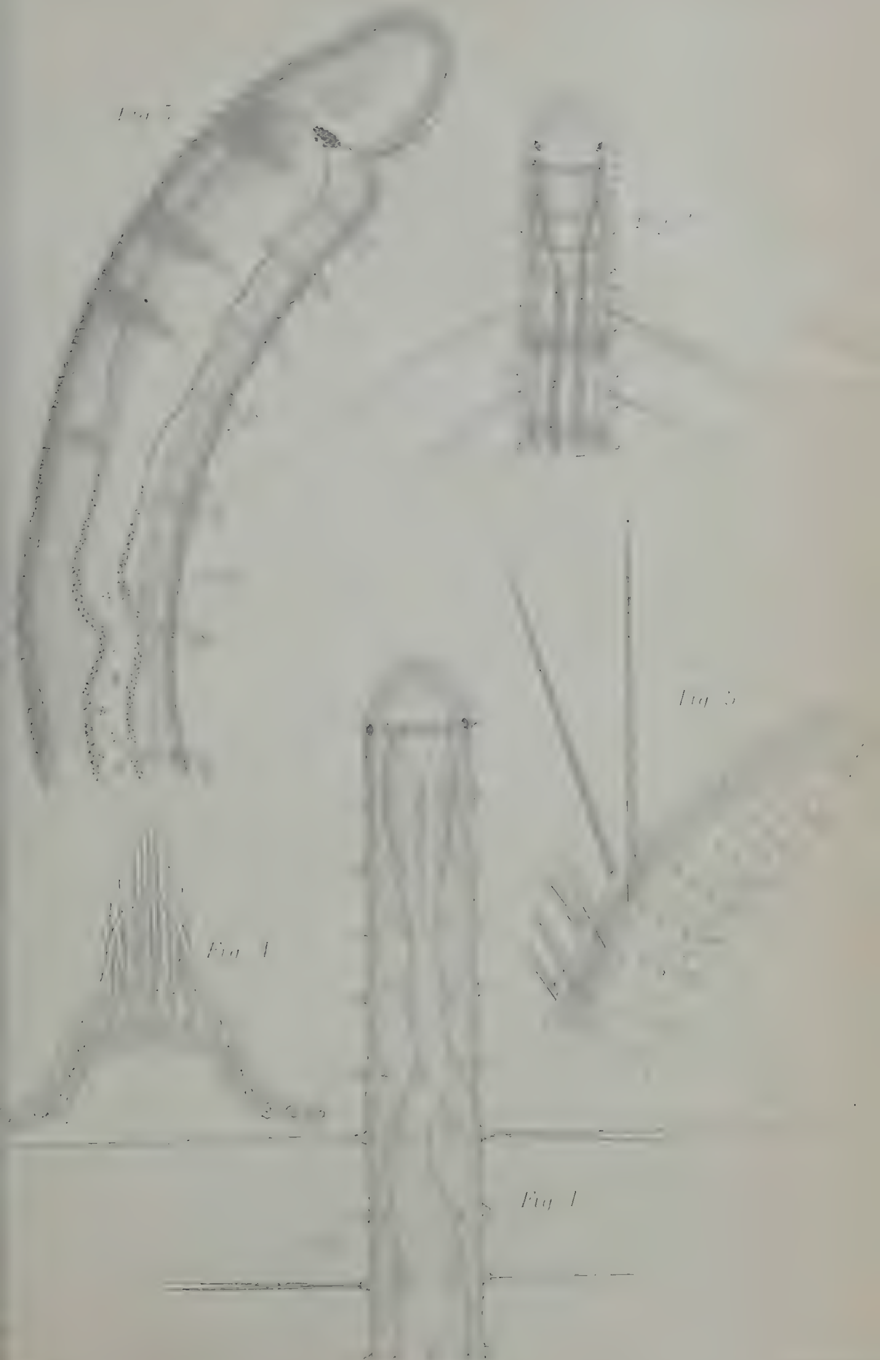
DESCRIPTION OF PLATE XXXIII.

Fig. 1. *Slavina lurida.* Ventral view, from life. × 90.
2. *S. appendiculata.* After D'Udekem, Bull. Acad. Roy. Belg. 1855.
3. *S. appendiculata.* After Vejdovsky, Syst. u. Morph. pl. iii. fig. 17.
4. Section of touch-organ. After Vejdovsky, *l. c.* pl. iii. fig. 21.
5. *Slavina serpentina.* Side view, from life. × 100.



4. S. APPENDICULATA. 5. S. SERPINTINA

On some undescribed Acari of the genus *Glyciphagus*, found in Moles' Nests. By Albert D. Michael, F.L.S., F.Z.S.

[Read 18th February, 1886.]

(Plates XXXIV. & XXXV.)

For some years past I have been, from time to time, investigating the life-histories of some Acarine parasites of the Mole, and in the Christmas of 1885, being for a short time in one of our midland counties, I continued the inquiry. There were, however, a few points which I could not succeed in elucidating, and it struck me that I might possibly obtain the information I desired, if, instead of continuing to search the Moles themselves, I examined their nests.

I do not, of course, propose to give any description of so well-known a structure as the "fortress of the mole," but I may be excused for referring for a moment to the nature of the actual nest in the twelve examples which I dug up and examined. Inside the domed earthen chamber, and about a foot below the surface of the ground, was the nest—an almost globular structure about six inches in diameter, composed of dried grass and dead leaves; the former usually forming the exterior, and the latter the interior of the ball, although the two classes of material were not strictly kept separate. In the larger number of the nests I found but little; in three or four, however, which, when I dug them up, I had remarked as appearing to be fresh nests, the case was very different.

On opening the first of these nests, and putting a portion under a microscope with a low amplification, I was surprised to see before me several Acari quite unknown to me, and very remarkable, which I also found in the other fresh nests, so that my search, whether it serves the original purpose or not, has not been fruitless. Amongst them were two closely-allied, but very striking species, which I believe to be new to science, and it is with these two species that I propose to deal in the present paper. They were both found chiefly between the leaves in the interior of the nest, and an examination showed that they belonged to the genus *Glyciphagus*, although presenting some rather exceptional characters. They were not uncommon, and I was therefore able to secure sufficient material to give a fairly complete account of them in all stages.

The genus *Glyciphagus* was instituted by Hering * in 1835, for an Acarus which he found feeding on dried fruits. It is to be feared that many of the species which have been added to it by subsequent authors do not properly belong to it. In the year 1867, however, MM. Fumouze and Robin † took considerable trouble to define the genus, and the leading characters of that definition may probably be fairly summarized (somewhat as by Andrew Murray ‡) as Tyroglyphidæ with long tarsi, a rough (granular) skin, with feathered, pectinated or palmate hairs; and the females whereof are provided with a short, tubular projection in the median line of the hind margin, which Murray calls "an anal button."

In 1868, Robin § found it necessary to modify this definition, so far as the plumose condition of the hairs was concerned, in order to include a species discovered and called by him *Glyciphagus hericius*, which had simple setiform hairs.

Fumouze and Robin divided the genus into two parts: the second division, which they call "*Glyciphagi* with plumose or palmate hairs," has the skin more strongly granular, the abdomen broader and flatter, the tarsi shorter, and the hairs shorter, but otherwise much more developed than in the first division. The Acari which I am about to describe clearly belong to this second division; but in order to admit them, it is necessary to modify the subgenus as Robin modified the genus, for the hairs in this instance are not developed into plumes or leaf-like structures, but into strong, thick spikes.

Fumouze and Robin's subgenus contained only two species, viz. *G. plumiger* and *G. palmifer*; and it is not strange that other curious species should be added to the division which contains these very beautiful and remarkable creatures.

I ventured early in 1879 to point out that the anal button, or tubular projection, which acarologists then apparently considered as a useless ornament, was really the bursa copulatrix,

* "Die Kräzmilben der Thiere und einige verwandte Arten." Nov. Act. Acad. Leop. t. xviii. pt. xi. p. 619.

† "Mém. anatomique et zoologique sur les Acariens des genres *Cheyletus*, *Glyciphagus* et *Tyroglyphus*." Journ. de l'Anat. et de la Physiol. (Robin), t. iv. (1867), p. 568.

‡ Economic Entomology, London, 1876, p. 276.

§ "Recherches sur une espèce nouvelle de Sarcoptides du genre Glyciphage." Journ. de l'Anat. et de la Physiol (Robin), t. v. p. 604.

which was post-anal, and far distant from the organ called the vulva, which was used only for the deposition of ova. I believe that the correctness of this view is now generally admitted, not only with regard to the genus *Glyciphagus*, but, as far as the position of the bursa and organs of oviposition respectively are concerned, in the Tyroglyphidæ generally. If this view were not admitted the present species would give an excellent opportunity of establishing it, as will be seen by the remarks which will be found below on the species which I propose to call *G. dispar*.

At the end of this paper I have given the usual detailed description of each species, but I will here call attention to what seems to me to be the more interesting features connected with them.

What strikes the observer first is naturally the singular general appearance of the creatures, produced by the great size of the abdomen as compared with the cephalothorax, by the broad, flat form and almost horseshoe-shaped outline of the latter, and specially by the lateral margins (and in some instances the other margins) being raised and cut up into large, irregular, rough, bifid or trifid lobes; most of these lobes bearing a single extremely large spine or spike, either curved or straight, of clear, hard chitin, which give the animal a very strange, and, when freshly emerged and the skin is like frosted silver, a very beautiful appearance. A little observation, however, discloses something more worthy of attention by the biologist than the bizarre appearance, which is this. In the genus *Glyciphagus* it is usual to find a well-marked distinction between the sexes, the male being usually considerably smaller than the female, often not above two thirds of the length, and rather less than the proportional breadth; the hairs are less plumose or palmate, and the posterior projection is of course absent. These differences, although very apparent, are after all comparatively slight modifications, not greater than exist between the sexes in other genera of the same family, and not such as to cause the least surprise at the creatures belonging to the same species. In the larger of the two Acari now being described, and which I propose to call *G. platygaster*, the ordinary rule of the genus in this respect is well carried out. The sexes show considerable differences, but are alike in general character, and would be taken at once for the male and female of the same species. The male is the smaller, in about the customary proportion, and has the lobes and spikes round the hind margin

as well as the lateral margins; while the hind margin of the female in the neighbourhood of the bursa is straight and spikeless. The object of this is of course manifest. There are considerable differences in the epimera and ventral surface, &c., but these differences are, after all, comparatively slight modifications. When we come to deal with the second species, *G. dispar*, we find that the female is very like that of *G. platygaster*; it is very much smaller, and presents such well-marked specific differences that no naturalist, however averse to species-making, would think of considering them as identical; but, on the other hand, every one would admit that they were closely-allied species, and this whether they regarded general appearance or minuter structure. On turning to the male, however, the case is entirely different. It is utterly unlike both the male of *G. platygaster* and its own female; and I venture to think that no arachnologist who had not found them *in coitu*, would have supposed the male and female to belong to the same species or genus, probably hardly to the same family or subfamily. The male is not above half the length of the female, and, contrary to the ordinary rule in the genus, its breadth is rather greater in proportion to its length than in the female. The abdomen is broadest in front and narrowest behind, exactly contrary to what occurs in the female; the raised edge, the bifid or trifid lobes, the great spines or spikes—all of which characteristics form the principal features both of its female and of both sexes of the larger species—are entirely absent. The great spines are replaced by a few minute points, and there are not any hairs on the body; again, the legs, instead of being long and slender, as in the female, are short and thick; the two hind pairs are entirely hidden beneath the abdomen: and indeed the whole creature seems quite different. It does appear to me very strange in a genus where the males and females generally have only moderately marked differences, that in two species, the females of which are so closely allied, one should have a male resembling the female as nearly as is usual in the genus, and the other should have a male so extremely dissimilar When we look at the fact that the two species are found in the same place, and apparently under precisely the same conditions in all respects, the question arises what can have been the cause of this remarkable variation, and to that question I confess I cannot at present offer any satisfactory explanation; it is difficult to understand how survival of the fittest can have produced it.

I have said that I should not have supposed the creatures to be different sexes of the same animal had I not found them *in coitu*; but this I did, not in one case only, but in very numerous instances, so that there cannot be any doubt about it.

This brings me to another branch of my subject, viz. the satisfactory proof which this species affords that the posterior projection of the females is the bursa copulatrix. In most species of this genus and its close allies, and in the *Dermaleichi*, the coitus lasts a long time, as in the Lepidoptera, with this difference between the Acari and the Insects, that whereas in the latter the pair remain mostly stationary, in the former they keep in almost constant motion; the female, which is the larger and more powerful creature, dragging its companion. In the present species, *G. dispar*, the disproportion in the size of the sexes is so great that the female does not drag, but carries the male, the anterior half of the male lying on the dorsal surface of the hind part of the abdomen of the female, which is clasped by the two front pairs of legs of the male, whose two hind pairs, usually directed backward, are now bent directly forward on the ventral surface of the female. Her abdomen is thus clasped by all the legs, and so firm is this grasp that not only may the pair be removed to the microscope and placed under a cover glass, and both the dorsal and ventral surface examined without its becoming relaxed, but it is even possible to make permanent microscopical preparations of the two *in situ*—one of these preparations being shown on the occasion of reading this paper. The drawing of the pair in position (Pl. XXXV. fig. 8) was drawn from the life with the assistance of such a preparation. This peculiar position of the hind legs, the absence of hairs from the male, and the flatness of its underside, enable the position of the organs to be most clearly seen, and would alone settle the question of the bursa copulatrix if it were still in doubt. There is, however, an additional and interesting piece of evidence. It was pointed out by Haller, in a paper dated November 1879*, that in *Tyroglyphus setiferus* the post-anal copulative opening of the female, which is in this case a mere pore, not a projection, led by a very short neck into an almost globular receptaculum seminis. This has lately been carefully worked out by Dr. Alfred Nalepa, in the

* "Zur Kenntniss der Tyroglyphen und Verwandten" Zeitschr. f. wiss. Zool. xxxiv. Bd. p. 288.

cases of *Tyroglyphus longior* and *Tyroglyphus* (*Trichodactylus*) *anonymus* *. In these cases also the duct between the bursa and the receptaculum is extremely short, indeed scarcely marked. In the present species, which belongs to a different genus, the duct is long and slender, as will be seen from Pl. XXXIV. fig. 14 *d*, which is drawn from an actual dissection, not from sections; the duct may however be clearly seen in the living creature when one has become acquainted with its position by dissection.

The construction of the articulation of the tarsal joint of the two hind pairs of legs of the male in both species is worthy of notice; it is evidently of use in giving great play to the joint for clasping purposes; it will be found in the descriptions of *G. platygaster*, and in fig. 9, Pl. XXXIV., and figs. 15, 16, Pl. XXXV. Lastly, a curious little matter is the existence of a singular hair (Pl. XXXIV. fig. 12), not above $\frac{1}{1000}$ inch long, on the side of the body of the male, between the coxæ of the first and second legs; this minute hair is so branched as to resemble a tuft of fine Algæ; its size and position prevent it from being seen on the whole creature; I only discovered it on dissections of the exoskeleton. I am not sure whether it exists in the female. A somewhat similar hair, similarly placed, was discovered by Dr. Kramer on *Glyciphagus ornatus* †. Dr. Kramer says that the hair in his species stood before a minute opening; I did not see an opening in the present species, but it may exist.

It remains to be considered what is the connection between these *Glyciphagi* and the Mole, and this is far from an easy problem to solve. I have now been in the habit of examining fresh Moles for some years, whenever I could get them, and have examined a large number. I caught twelve Moles this Christmas, in the same fields from which I dug up the nests as above mentioned, and at the same time; and yet I have never seen a sign of one of these *Glyciphagi* in any stage upon a Mole.

On the other hand, in all my searches for Acari in moss, grass, and leaves, extending over many years, and continued at the time and place of obtaining the above Moles' nests, I have never seen a specimen of either of the present species; nor were there any in those nests, which from external appearances I had supposed to be old and abandoned. This subject is one

* "Die Anatomie der Tyroglyphen." Sitzgsber. der k. Akad. der Wissensch. Wien, xc. Bd. 1 Abth. p. 197 (1884); ibid. xcii. Bd. 1 Abth. p. 116 (1885).

† "Ueber Milben." Zeitschr. für die gesammten Naturw., liv. Bd. (1881).

requiring further investigation, and at present I am not prepared to give an opinion on it.

GLYCIPHAGUS PLATYGASTER, n. sp. (Plate XXXIV., and Plate XXXV. figs. 1–5.)

	Female.	Male.
Average length, about	·76 mm.	·54 mm.
,, breadth, about	·65	·44
,, length of legs, 1st pair, about	·35	·32
,, ,, 2nd ,,	·32	·25
,, ,, 3rd ,,	·38	·28
,, ,, 4th ,,	·46	·41

Colour, when just emerged, pure white, afterwards cream-white to parchment-colour, or with a pinkish shade; the male sometimes a little darker; legs and rostrum light pinkish-brown; all the colours opaque.

Texture of the body rough and granulated, like shagreen. The male is the rougher. The result of this is that all the edges of the body appear to be, and actually are, covered with a thickly-set series of irregular projecting dots, or short blunt points.

Female.

Cephalothorax small, short, and conical, with curved sides; less than one sixth of the total length of the creature, as seen from above. Rostrum or epistome, rather obtuse, forming a hood above the mandibles, which project, giving a pointed appearance. The two rostral hairs are thick, stiff, and strongly curved downward; further back (on the dorso-vertex) are two powerful spikes directed forward, springing from large papillæ placed near together and almost close to the anterior margin of the abdomen. Mandibles (fig. 7) large, short, tridentate. Maxillæ (so-called) (fig. 6, *mx*) plain, not dentate, and of clear colourless thin chitin. There is a well-marked chitinous skeleton supporting the labial parts and projecting inward, as indicated in fig. 6. Palpi three-jointed, lower joint anchylosed to labium (Plate XXXV. fig. 4). Lingula triangular, somewhat spoon-shaped, of clear membrane.

Legs very thin in proportion to the size of the creature, rather short; fourth pair passing the hind margin by rather more than half the length of the tarsus. The two front pairs spring from large, rounded, chitinous projections at the edge of the lower part of the cephalothorax, having rough chitinous knobs at their posterior angles; the third and fourth pairs are set well under

the body. The legs themselves diminish gradually in thickness from the proximal to the distal ends, and each is terminated by a very small single claw, furnished with a sucker or caruncle. The coxæ are short and rounded, the tarsi nearly as long as the three previous joints, which are not far from equal to one another in length. The tibiæ of the first three pairs of legs bear long, flexible, tactile hairs, which are present, but very small, in the fourth pair; where possibly they are useless in consequence of these legs being usually almost entirely beneath the abdomen. The other hairs on the legs are stiffer and more spine-like in character. They are as follows, viz.:—a pair on the third joint of each leg, those on the two front pairs of legs being opposite, and strongly curved downward and inward, and slightly serrated; a very strong, somewhat similarly curved spine springs from the underside of each tibia near its distal end; there are two or three short spines on the underside of each tarsus, and one, rather larger, on the upper side of that of the second pair.

Abdomen large, gradually increasing in width from the anterior until near the hind margin; the increase is, however, more rapid in the first third of the abdomen. The anterior and posterior margins are almost straight. The dorsal surface of the abdomen (notogaster) is considerably raised above the cephalothorax, and is almost flat in general level, but its lateral edges form bands which are depressed at their inner and slightly raised at their outer sides, and its anterior and posterior edges are somewhat depressed. From the inner edges of the bands the abdomen is slightly arched upward, but it forms a very low flat arch rising but little above the outer edge of the bands; the extent of the arching varies in different specimens and at different ages, and there are often vague irregular depressions in the surface. Along the outer edge of the lateral band, on each side of the abdomen, are ten singular projections, often having markings of darker colour at their bases; the first of these is at the angle of the anterior and the tenth at that of the hind margin. The first, third, and tenth are single and papillous; the second, fifth, and sixth single, but less projecting, and directed backward in a somewhat hooked form; the fourth and ninth have an approach to a bifid form, and the seventh and eighth are decidedly trifid. From each projection, except the second, fifth, and sixth, springs a large and powerful pointed spine more or less radial in position; those that spring from the first, third, fourth, and ninth projections

are decidedly, but not strongly, curved; the others are straighter. In the centre of the hind margin is the projecting "button" characteristic of the females of this genus, and which is really a bursa copulatrix; it is rather unusually long, and directed slightly upward. Down the back are two rows of fine strong spines, of which the first is directed forward and the others backward; the third of these is the longest and the fourth the shortest. There is also a very long spine between the third and fourth, but nearer to the lateral edge of the abdomen. The underside is much arched and projecting in the centre, the edges being thinner and flatter.

The sternum is short, and coalesces with a chitinous band behind the labium, to which also the epimera of the first pair of legs are joined. The epimera of the second pair are free, not joined to any other skeletal sclerites. The epimera of the two hind pairs of legs are joined together at their inner ends by a cross-piece; none of the epimera quite reach the vulval sclerites, although they approach very close. The vulva (of oviposition) (fig. 15) is large, placed far forward, its anterior end being between the coxæ of the second pair of legs; it is protected anteriorly by a thick chitinous piece of a pointed-arch shape, the point forward, and posteriorly by a more rounded and thinner piece fitting within the arch, so that the whole form a ring with an anterior point and free lateral projections. The labia extend the whole length of this ring; they bear two pairs of very minute hairs on their exterior. The anal opening is long, almost at the hind margin; it has projecting labia lying together like knife-edges, and is bordered by five pairs of spines of various sizes, of which three form a triangle on each side.

The alimentary canal (fig. 13) is of the usual type. A short œsophagus (part shown at *œ.*) leads into a large ventriculus (*v.*) wider than its length, and furnished with two large, but short, cæcal appendages (*c.*); this is sharply divided from an almost globular colon (*co*), and wide, elongated, funnel-shaped rectum (*r*). The bursa copulatrix (fig. 14, B) leads by a long, thin, flexible, hyaline, sperm-duct (*d.*) into a large yellowish sac, the receptaculum seminis (*r. s.*), which communicates by two very short but wider ducts with the paired ovaries (*o. o.*), which again lead into the long much-looped oviducts (*od. od.*), in which the eggs may be found in all stages of development.

Male.

The smaller size is what strikes the observer first. It will be seen by the measurements that the male is three quarters or two thirds of the length, and is about two thirds of the breadth of the female; the difference in size being almost entirely in the abdomen. With the exception of the size, there is a great resemblance between the sexes; and although there are numerous and considerable differences in detail, they are not greater than those usually found between the male and female in this genus; no one would doubt their belonging to the same species.

Cephalothorax similar to that of the female; but the papillæ, from which the two spines of the dorso-vertex spring, are not so large or projecting as those of the female. The sternum is longer than that of the female, but otherwise similar; a chitinous cross piece joins the inner ends of the epimera of the second, third, and fourth pairs of legs, instead of only the last two. There is a singular branched hair (fig. 12) on each side of the body, between the coxæ of the first and second pairs of legs; it is very minute, not above ·025 millim. long; I could not see it on the creature itself, and only discovered it from dissections of the exoskeleton.

Legs.—These are stouter and are longer, in proportion to the abdomen, than those of the female; the tarsal joints, however, are considerably shorter and more conical than those of the opposite sex; and the tibiæ, particularly in the two hind pairs of legs, and also the third joints of the fourth pair of legs, are very much longer in proportion. There is another singular arrangement in the two hind pairs of legs which is entirely absent in the female. These legs have a decided curve inward, and the third and fourth joints, particularly the fourth joint of the fourth leg, increase rapidly in thickness at their distal ends, the whole increase being on the inner side, so that this, at the distal end, projects, forming a large curved point, from which the tarsus curves away, forming the lower side of the point. To enable this construction to work, the articulation, although close on the outer side, is exceedingly loose on the inner side, the two joints being there attached by a flexible membrane of considerable width, generally bowed outwards, giving great play to the tarsus, probably for clasping purposes. The hairs on the legs differ very little from those of the female, but the third and fourth tarsi of the

male have a singular assemblage of small, chitinous, recurved knobs or hooks at their distal ends (fig. 11).

Abdomen.—This is rounded posteriorly, instead of having a straight hind margin like that of the female. It has ten projections along each side, the same number as the female, but they are larger and differently arranged, as there is greater distance between the first and second, the fact being that what would correspond to the second in the female is rudimentary in the male, the second in the male corresponding to the third in the female. On the other hand, the posterior projections extend not only along the lateral but also along the hind margin, the two tenth projections coming close together in the median line, leaving a deep narrow cut between them; this is partly due to the fact that the last spine of each dorsal longitudinal row is borne, not on the notogaster, but on a large projecting papilla on the hind margin, which forms the tenth projection of the male, and almost coalesces with the ninth projection. Bearing these differences in mind, so as not to be confused by the numerical order of the projections (*i. e* remembering to count the rudimentary second projection), the forms of these projections, the spines they carry, the marginal bands and arching of the notogaster, and the spines upon it, correspond fairly well with the equivalent parts in the female. The copulative organs are placed in the median line between the insertions of the third and fourth pairs of legs. The anus is placed further forward than in the female, and is surrounded by a chitinous band (fig. 5); it is protected by two pairs of very large spikes near its posterior margin, the outer pair being the longer.

The Nymph.

This is easily known from its similarity to the adult, but there are, of course, numerous differences. In the fully grown nymph the sex is well marked; the bursa copulatrix and other external sexual organs of the female are easily seen; so that the male and female nymphs are somewhat different, but not so much so as the adults. Taking the fully-grown female nymph, it will be seen that it is almost white, without the pinkish shade of the adult. The legs are about the size of those of the adult, but the abdomen is considerably smaller and more square in shape; its edges are more raised and its central part more depressed than the corresponding parts of the adult. The rough projections

round the periphery, instead of being separated by spaces and absent from the hind margin, as in the adult, form an almost continuous line round the lateral and posterior margins. It is evident that the spikes carried by these projections will thus afford greater protection to the creature during growth, and at the period of life when the object of the straight hind margin of the adult has not arisen.

The Larva.

This has much the same characters as the nymph, except that it is smaller, more transparent and compact, with the raised edge less strongly marked, and it is, of course, hexapod.

GLYCIPHAGUS DISPAR, n. sp. (Plate XXXV. figs. 6–17.)

	Female.	Male.
Average length, about	·35 mm.	·17 mm.
„ breadth, about	·24	·13
„ length of legs, 1st pair, about	·16	·10
„ „ 2nd „	·14	·8
„ „ 3rd „	·13	·9
„ „ 4th „	·19	·9

Colour, when just emerged white; afterwards the female is light reddish brown, darker and redder than that of *G. platygaster*. The spaces on the underside enclosed by the sclerites surrounding the genital and anal regions remain pure white. The male is dull light grey, considerably lighter than the female, and entirely without the red tinge.

Texture of the female very similar to that of *G. platygaster*; the male, however, is different, being covered with small hemispherical bosses or dots, much larger in proportion to the size of the creature, and much rounder and more regular.

Female.

Very similar, except in size, to that of *G. platygaster*, although there are numerous well-marked specific differences, particularly in the abdomen and the epimera and other chitinous pieces of the underside.

Cephalothorax.—Similar in almost all respects to that of *G. platygaster*, except that the hairs of the dorso-vertex do not spring from papillæ. There is not any true sternum. The vulva of parturition, which is very large, extending from the level of the insertion of the lower edge of the first leg nearly to that of the

insertion of the third leg, consists of two large, slightly chitinized labia somewhat separated posteriorly; it is entirely surrounded by a chitinous band or sclerite (Robin's sternite) at some distance from the labia laterally, but almost touching them at their lower most separated part. The chitinous ring is thickest at the sides and thinnest posteriorly. Chitinous epimera, or bands, start from above the first leg, below the second leg, and between these two legs, and all run radially inward, joining the vulval sclerite above described. The epimeron in front of the third leg is a short curved piece, often almost obsolete, running forward, and nearly, but not quite, touching the epimeron from below the second leg about its middle. The epimeron behind the third leg is a somewhat similar, but more strongly marked, piece pointing toward the lower part of the vulval sclerite, but not nearly reaching it. There is scarcely any epimeron to the fourth leg.

Legs very similar in all respects to those of *G. platygaster*, but rather thicker in proportion. The hairs are practically similarly placed.

Abdomen resembling that of the female of *G. platygaster* in general form, but not quite so wide in proportion to its length, and the *hind margin is totally different*, for, instead of being straight, it is entirely occupied by two great rounded lobes directed backward; the projecting "anal button" (bursa copulatrix) is sunk in the indentation between the two lobes. There are nine projections on each side, instead of ten as in *G. platygaster*. These are usually all more or less bifid or trifid; they are irregular in form, each one, except the second and sixth, serving as the point of insertion of a very strong pointed spine, thick at the base and gradually narrowing. The first of these spines points forward, the others, instead of being nearly radial as in the last species, are strongly curved, often having a tendency to a double curve, and are directed first outward and then backward, so that the distal portion is nearly parallel to the side of the abdomen. *There are not any spines on the notogaster except two so close together that they generally look like a single large one* in the median line a little behind the centre, and a pair of much smaller spines further forward. The anal opening is large, placed rather far forward, and entirely surrounded by an elliptical chitinous ring, within which the whole anal region is white. There are two pairs of spines of moderate size near the hinder part of this ring,

and a pair of larger spines on the underide of the abdomen, further back and more to the side.

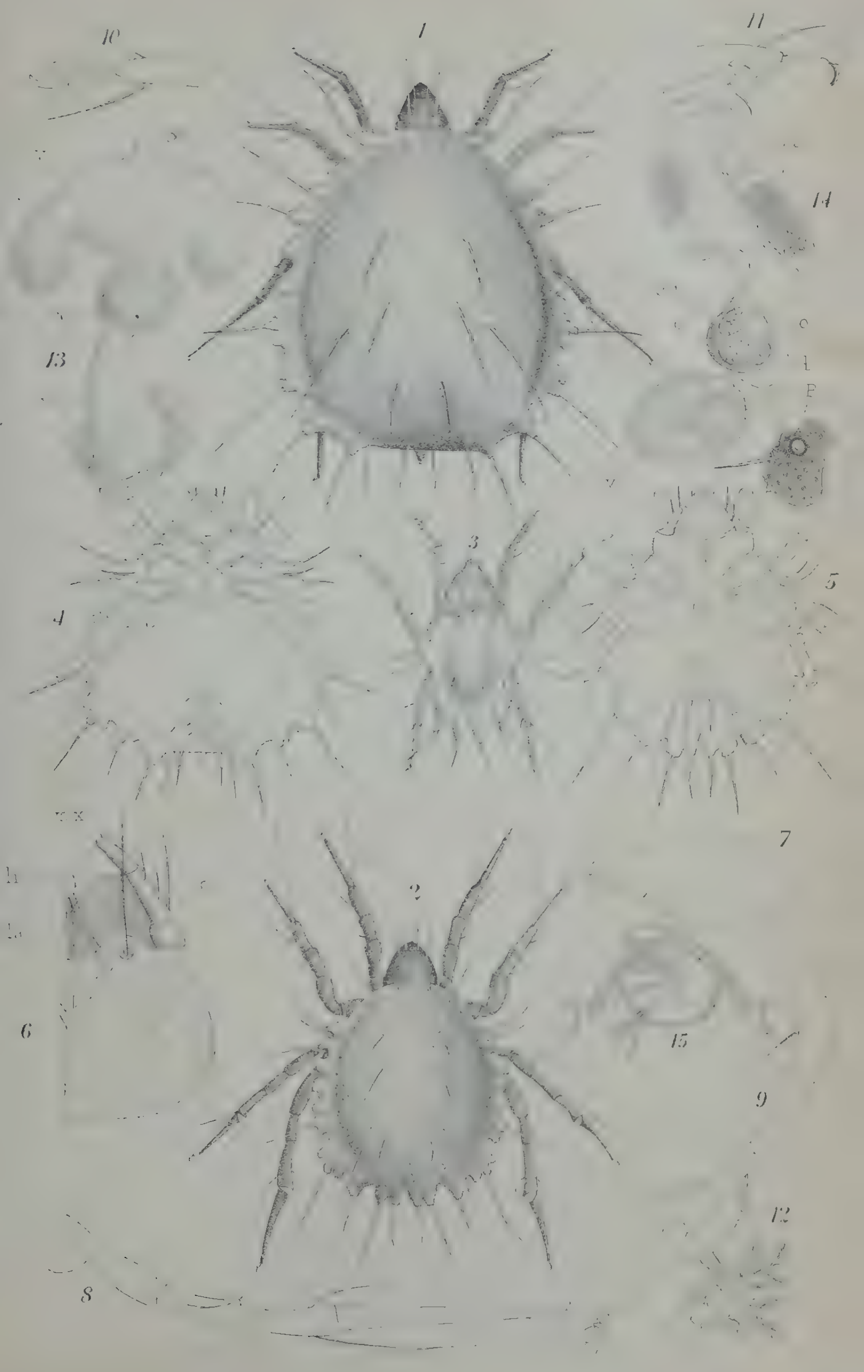
Male.

This is quite unlike the female in appearance; irrespective of the extreme difference in size, and the difference in colour and texture before referred to, the legs and abdomen are quite dissimilar.

Cephalothorax much like that of the female, but without the hinder of the two pairs of spines conspicuous in that sex, and having the front pair very small and exactly at the angle of the epistome. The trophi, particularly the palpi, seem to be well formed. There is not any true sternum nor any epimera to the second, third, or fourth legs; but there is an epimeral piece both above and below the first leg, which two are joined at their inner ends, and the lower is also joined to the outer penial sclerites (Pl. XXXV. fig. 17).

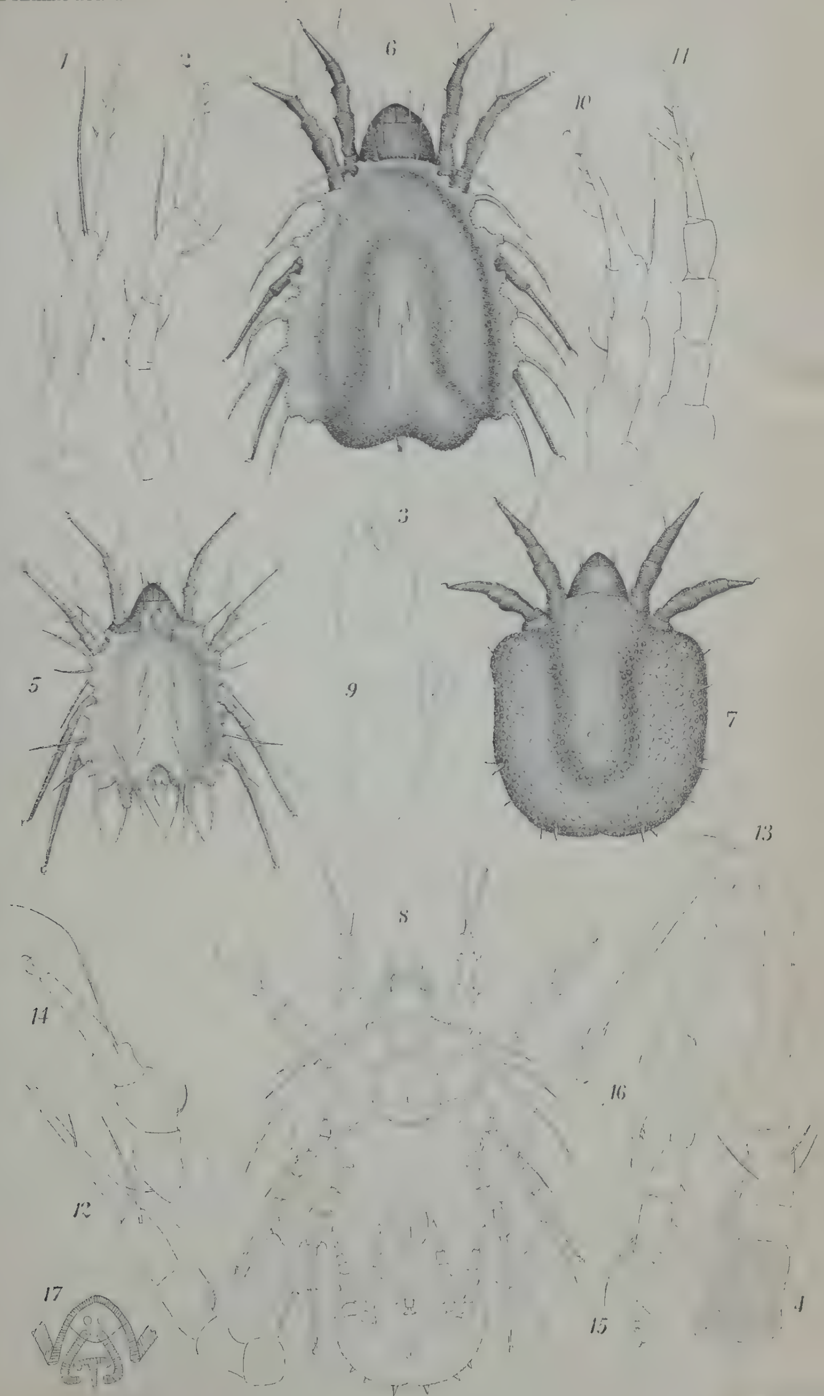
Legs short and thick, almost conical, but slightly curved. The two hinder pairs are wholly hidden beneath the body. The femora are somewhat bell-shaped, particularly in the two posterior pairs of legs (the two front pairs having an inward curve). The tarsi of the two hind pairs of legs are articulated in the same manner as those of the male of *G. platygaster*; but the arrangement is not quite so conspicuous. The caruncles are proportionally shorter and broader than those of the female.

Abdomen almost shield or spade-shaped, the anterior margin straight for the short distance where it joins the cephalothorax, then running outward and backward in a double curve on each side. The abdomen is widest at the anterior angle of the lateral margin, and gradually narrows backward. The hind margin is rounded. There is a low broad rounded elevation along the greater part of the median line, with a sulcation round it; otherwise the notogaster is flat. The abdomen is less thick in proportion, from dorsal to ventral surface, than that of the female. Round the edge are six or seven very small straight spines; the bifid or trifid projections and great curved spines of the female are entirely absent. There are three or four pairs of small spines on the notogaster similar to those round the edge. The anus is also protected by two pairs of spines.



GLYCIPHAGUS PLATYGASTER.

A D Michael ad nat. del.



1-5 GLYCIPHAGUS PLATYGASTER. 6-17 G DISPAR.

DESCRIPTION OF THE PLATES.

Plate XXXIV.

Glyciphagus platygaster.

Fig. 1. Adult female, dorsal view. ×65.
2. Adult male, dorsal view. ×65.
3. Larva, dorsal view.
4. Adult female, ventral surface. ×50.
5. Adult male, ventrol surface. ×56.
6. Half of the labial organs of the adult female, from below, ×300. *p*, palpus; *mx*, maxilla; *la*, labium; *li*, lingua. The skeletal strengthening of the labium and supporting organs are seen through the integument.
7. Mandible of adult male, seen from the side. ×300.
8. Fourth right leg of adult female, side view. ×150.
9. Fourth left leg of adult male, side view. ×150.
10. End of the tarsus of the fourth leg of the adult female, from above. ×450.
11. End of the tarsus of the fourth leg of the adult male, from the side, to show the projections. ×400.
12. Branched hair from the side of the body of the male, placed between the coxæ of the first and second pair of legs. ×600.
13. Alimentary canal, ×85; *æ*, part of the œsophagus; *v*, ventriculus; *c*, cæca thereof; *co*, colon; *r*, rectum.
14. Part of the female reproductive system, ×85. B, external opening of the bursa copulatrix, which is drawn as advancing straight towards the eye, and attached to a portion of the surrounding integument; *d*, sperm-duct; *r s*, receptaculum seminis; *o*, *o*, ovaries; *o d*, *o d*, portions of the oviducts.
15. The vulva of oviposition, seen from within, showing on the left the muscles (retractores labii), and on the right the (so-called) suckers.

Plate XXXV.

Glyciphagus platygaster, figs. 1–5.
Glyciphagus dispar, figs. 6–17.

Fig. 1. *Glyciphagus platygaster.* Adult female, first left leg, from above. ×150.
2. —— ——. Adult male, third left leg, from the outer side. ×150.
3. —— ——. Adult female, mandible, from below. ×150.
4. —— ——. Adult female, left palpus, from below. ×400.
5. —— ——. Nymph.
6. *Glyciphagus dispar.* Adult female. ×130.
7. —— ——. Adult male. ×200.
8. —— ——. Underside of adult female, showing male *in coitu.* Both drawn to the same scale, viz. ×130.
9. —— ——. Adult female, mandible. ×400.

Fig. 10. *Glyciphagus dispar.* Adult female, first left leg, from above. ×300.
11. —— ——. Adult female, second left leg, from above. ×300.
12. —— ——. Adult female, third left leg, from above. ×300.
13. —— ——. Adult female, fourth left leg, from above. ×300.
14. —— ——. Adult male, first left leg, from above. ×400.
15. —— ——. Adult male, third left leg, from above. ×400.
16. —— ——. Adult male, fourth left leg, from above. ×400.
17. —— ——. Adult male, arrangement of the intromittent organ and surrounding sclerites, &c.

Description of *Strongylus Arnfieldi* (Cobb.), with Observations on *Strongylus tetracanthus* (Mehl.). By T. Spencer Cobbold, M.D., F.R.S., F.L.S., Hon. Vice-Pres. Birmingham Nat. Hist. and Microsc. Society.

[Read 4th March, 1886.]

(Plate XXXVI.)

It has been commonly taken for granted that all the Nematodes hitherto found to infest the lungs of Solipeds are referable to the species which proves so destructive to young cattle. On the authority of Eichler in the one case and of Gurlt in the other, Diesing states that the cattle Strongyle (*Strongylus micrurus*) infests *Equus caballus* and *E. asinus*. As regards the horse I have verified Eichler's find, but as regards the ass it happens that all the lung-worms carefully examined by me are of a different species. This circumstance does not, of course, disprove the accuracy of Gurlt's position, but rather renders it probable that at least two nematode-species infest the lungs of both hosts.

On the 1st of December, 1882, Mr. Arnfield, at that time a pupil of the Royal Veterinary College, brought me some worms removed from the trachea and bronchi of a donkey. The batch comprised three males and ten females, most of the latter being much injured. Guided by their size and general aspect it was easy enough to suppose that the worms were examples of *Strongylus micrurus*; but a microscopic examination showed that the naked-eye appearances were deceptive. The worm, in fact, was new to science, and it was accordingly named after its discoverer. To secure priority in the finder's favour a brief description followed in the pages of 'The Veterinarian' (Jan. 1884), but no figure of the worm has hitherto been published. Subsequent to

the date above mentioned many other examples were from time to time submitted to my notice,—another pupil, Mr. Hassall, procuring and mounting these worms with much success.

STRONGYLUS ARNFIELDI (*Cobb.*).

Mouth simple; œsophagus short, slightly constricted; body with very fine striæ; vulva of the female a little above the anus; tail of male with trilobate hood, rather broader than long; rays complete, posterior ray broad and united to its fellow at the base, bifurcate at the end; mid ray narrow, cleft to the centre; postero-lateral ray long, variable in width; spicules equal, with an accessory piece; tail of female short, sharply pointed. Viviparous. Males $1\frac{1}{2}$ inch long; females 3 to $3\frac{1}{2}$ inches.

Hab. Trachea and bronchi of the ass (*Equus asinus*).

The anatomical points that call for special notice are such as refer to the morphology of the hood and its rays, to the position of the vulva, and to the structure of the embryo. The ray-pattern contrasts strongly with that of *S. micrurus*. I have recently verified Schneider's description of the rays of *S. micrurus*, ray for ray. Unpublished figures in my possession show only a relatively greater length of certain rays than Schneider's original plan suggests. This applies more particularly to the anterior ray. In my specimens of *S. micrurus* the innermost division or cusp of the trifid end of the posterior ray is also more strikingly pronounced. Contrasting the hoods of *S. micrurus* and *S. Arnfieldi*, the disconnected character of entire series of rays at their bases is of itself sufficiently distinctive of the former species; whilst, as regards the individual rays, I need only further refer to the paramount aspect of the posterior ray and its bifid extremity in *S. Arnfieldi*. Equally diagnostic of *S. Arnfieldi* is the position of the reproductive outlet in the female, which is placed above the anus at a distance of only 1 millim. from the end of the tail. In *S. micrurus* the distance is 18 millim. (Schneider). The eggs occur in prodigious numbers, probably in excess of what is seen in *Strongylus filaria* of the sheep, in which species, according to Mr. Beulah, each female carries 300,000 embryo-containing ova. My original estimate for *S. micrurus* was one third of this number. The viviparous character of *S. Arnfieldi* is readily tested by pressure under a cover-glass, when embryos will escape from the vulva. An embryo thus freed already shows a well pro-

nounced intestinal canal, the œsophagus and hind gut being both clearly defined. The mid gut is obscurely cellular in my preserved specimens. Of more interest is the form of the embryo, whose sharp tail supports a distinct, though excessively minute, bristle-like piece at the end. The base of this appendage does not exceed the $\frac{1}{2000}$ of an inch in diameter. It may be added that the presence of a small or third spicule in *S. Arnfieldi* is not distinctive, as I have found a similar arrangement to obtain in *S. micrurus*, which has hitherto escaped observation. The little piece is about $\frac{1}{666}''$ long in the last-named species.

In view of diagnosis the following approximate measurements may be found useful. Diameter of the body of the male $\frac{1}{160}''$, of the female $\frac{1}{75}''$; each large spicule $\frac{1}{100}''$ in length by about $\frac{1}{850}''$ broad; œsophagus of the male $\frac{1}{45}''$ long; anus $\frac{1}{100}''$ distant from the end of the tail; vulva $\frac{1}{25}''$ from the point of the tail; eggs containing coiled embryos $\frac{1}{350}''$ long by $\frac{1}{400}''$ in breadth; free embryos $\frac{1}{100}''$ in length, and rather less than $\frac{1}{2000}''$ in breadth; base of the tail opposite the anus $\frac{1}{5000}''$ broad, and the bristle-like extremity from $\frac{1}{20000}''$ to $\frac{1}{50000}''$ only.

Turning to *Strongylus tetracanthus*, my object is to contribute a few facts towards a more complete knowledge of the structure and development of this common entozoon. What is at present known of its anatomy is chiefly due to Dr. Schneider. The importance of the worm in relation to the destruction of valuable animals is supreme; but inasmuch as Sonsino and others have already quoted my published results on this head, I refer those who are interested in questions of parasitic epizöoty to some of the papers cited below. I may, perhaps, be permitted to add that an exhaustive knowledge of the human parasitic epidemics can only be obtained by the study of similar outbreaks affecting animals; and that in both cases any advances made towards combating the evils thereby produced can only rest upon natural-history facts, especially upon those of development.

On removing full-grown specimens of the four-spined Strongyle from the cæcum or colon of any Soliped, their bright red colour at once betrays the leech-like habits of the parasite. Even the perivisceral fluid itself is tinged. The males and females are of nearly equal size, varying from six to eight lines in length. Prof. Schneider has shown that, in addition to the so-called spines

of the head, there are two papillæ, one on each side of the mouth. These I have also seen. The fore gut has a complicated structure, more strikingly so than has hitherto been stated. The mouth leads to a strong buccal cup, supporting a circular series of short bristles (described and figured by Schneider, but only indicated by a dark line in my drawing), which separately have an extreme length of $\frac{1}{750}$ of an inch. The cup rests upon a muscular ring, which also supports a circular row of small chitinous processes. The ring is succeeded by an anterior œsophageal bulb, the lumen of which is bordered by chitin-plates. Then follows a broad muscular pharynx, through which the narrow chitinous cylinder of the lumen glimmers distinctly, leading down to the somewhat broader posterior bulb, which also displays thick dental plates. By these means an unusually powerful sucking action must result. The fore gut is next succeeded by a broad chyle-intestine marked at the upper part by regular constrictions, due to the presence of muscle-fibres which are connected at their periphery with nucleated muscle-cells that stretch across the perivisceral cavity. The constrictions become less marked towards the lower half of the mid gut, which latter finally ends in a short and narrow rectum, opening in the female at the base of a short conical tail. In some situations fine granules may be seen floating in the perivisceral fluid, and on one side of the œsophagus a particularly well-marked, colossal unicellular gland is visible. Concerning the sexual apparatus of the male I have little to add, except by way of confirmation of the views of Schneider as to the grouping of the rays of the hood. However, it is worth remarking that in examples of *Strongylus tetracanthus*, examined in February 1876, I found the innermost branch of the thrice-divided posterior ray supplied with an offshoot, which, in place of being quite rudimentary, was nearly as long as the primary branch itself. The spicules are narrow, and when retracted are closely applied to each other, so as to look like a single straight rod of uniform thickness. As regards the female sexual apparatus, the uterine horns and utero-vaginal passage were well seen in the example figured, the cavity of the uterus being crowded with ova near the fundus.

Respecting the skin and its appendages, I must explain that the large bristles of the neck described by Schneider were neither seen in the specimen here drawn, nor in any of the numerous

immature worms that I have examined. Figures 10 and 11 were copied from camera sketches.

It is the question of development that possesses chief interest. As Leuckart has pointed out, the young of this species have been frequently confounded with those of *Strongylus armatus*; especially by Colin and Ercolani (quoted below), the latter stating that the worm-capsules reach the size of a bean. Rudolphi first fell into this very natural error. In the spring of 1873 I first became practically acquainted with certain small encysted worms that had been removed from the intestinal walls of a pony by Prof. Williams of Edinburgh. The nature of similar finds had for many previous years puzzled both anatomists and helminthologists. In 1836 the celebrated Dr. Knox, who had received specimens from Professor Dick, pronounced these equine parasites to be "animals similar to *Trichina*." The systematist Diesing named the species *Nematoideum Equi Caballi*; and specimens were subsequently described by Messrs. Littler and Varnell as "extremely small Ascarides." Like others, I committed errors of interpretation, and (noticing differences of tail-contour which I correctly assumed to have sexual significance) regarded the young parasites as representing an independent species, which I provisionally named *Trichonema arcuata*. The error being explained, I yet think that on other grounds it will be convenient to speak of these immature worms as Trichonema-stages of growth, representing one of the biotomes of *Strongylus tetracanthus*.

When animals are largely infested by the larvæ of *S. tetracanthus*, the young worms first enter the walls of the intestine, and then proceed to encyst themselves in such abundance that throughout a great extent of the colon each square inch of the gut often contains fully one hundred immature Entozoa. In a bad case of infection I counted 39 Trichonemes or young Strongyles within the space of one-fourth of a square inch. In mild cases from two or three to a score may be detected. As obtains in Trichinosis, the amount of infection is a fair criterion of the degree of danger to which the host is exposed. There is, however, this difference, that whereas a fatal result may accrue to the equine host from the presence of a few thousands of young Strongyles within the intestinal walls, a similar disaster to the human bearer requires many millions of Trichinæ within the voluntary muscles. This is not an occasion on which to deal with pathological phenomena;

but as illustrating one step in the migratory process, I may mention that many of the larger and more superficially placed cysts display lesions of their walls, the young worms already protruding their heads. In short, I have taken them, as it were, in the very act of immigrating to the lumen of the intestine whence they had originally emigrated. Without detailing the pathological processes thus set up, it is sufficient to say that they afford irrefragable proofs of the dangerous character of this entozoon.

In any portion of a much-infested intestine it is usual to observe variations in the size of the cysts, each of which contains a single worm. As in some cases the sizes form natural groups, it is clear that the equine host may be infested by successive broods. Variations of structure are seen in the growing larvæ, but in the earliest encysted stage a well-formed intestine is invariably present. One of the smallest worms that I measured was only $\frac{1}{10}$ of an inch in length by $\frac{1}{130}''$ in breadth. In the advanced stage, in which condition the worm is about to re-enter the lumen of the host's intestine, one observes a distinct oral ring, a funnel-shaped buccal cup, a muscular œsophagus with the usual chitinous cylinder, and a strongly pronounced mid gut, presenting constrictions throughout the chylous portion and everywhere walled-in by large nucleated cells that are most conspicuous towards the rectum. Although thus far no structural differentiations mark the presence of internal sexual organs, the sharp-pointed tails of some of the worms and the short conical tail of others already point to differences of sex. The immature character of the worms was recognized by me from the first, but, as already implied, I was unable at the time to refer them to any of the hitherto known species*.

In Helminthology one must always be prepared for surprises.

* In 1831 Gurlt had recognized the circumstance that "die jungen Würmer liegen zusammengekrummt in der Substanz der Schleimhaut, wo sie wie scharze Punkte erscheinen." He spoke of two varieties of the sexual worm, and remarks:—"Auch die kleinere Varietät findet man in der Begattung." The largest of my so-called Trichonemes correspond in size with Gurlt's smaller variety of the adult worm, but as I never saw them in the condition he described they can hardly be the same. Dr. Krabbe's description of the cyst is similar to that of Gurlt, but he makes no mention of the helminthiasis thus produced. [For references, see Literature quoted below.—T. S. C.]

Thus on the 27th of February, 1874, I received from Mr. W. Cawthron, V.S., of Hadlow, a box holding forty little "cysts or bladders, each containing a worm." These cysts, as Mr. Cawthron termed them, were removed by him from fæces passed by a two-year old colt, together with Oxyurides and large Ascarides, from the presence of which the animal was suffering and rapidly "wasting away." Microscopic examination satisfied me that these so-called cysts were really fæcal pellets, the particles of which had been collected and held together by exudation from the young worms. The vegetable débris thus collected formed a kind of cocoon whose walls were made chiefly of vegetable parenchyma, as shown by plates of muriform and polygonal cells, chlorophyll, spiral vessels, and even raphides. Vegetable hairs and fibres also projected from the surface, here and there. Averaging the size of ordinary pills, some of the cocoons displayed the heads and tails of the enclosed worms standing out as finger-like processes. From one of these coccoons the projecting tail of the worm still retained a part of an old skin which the larva had not fully cast. I have reproduced a small drawing of this singular formation (fig. 15, Plate XXXVI.). In the history of the development of the Nematoids I know of nothing comparable to this cocoon-forming habit of *Strongylus tetracanthus*; and I venture to suggest that we have here a mechanical contrivance which possibly supersedes the necessity of the parasites seeking entrance to the body of an intermediary host. Be that as it may, the cocoon serves as a protecting covering whilst the young worm undergoes partial metamorphosis, attended with ecdysis. Internally, however, there were no visible traces of sexual differentiation. In one worm I noticed minute prominences which I supposed to be rudimentary cephalic spines. Within the pellets a hollow tube corresponds with the form of the enclosed larva, but I did not find any skin-cast within this cavity. Whether my interpretation of the facts be correct or not, future investigations must determine. A missing link, representing a transition from the cocoon-stage to the young and unimpregnated sexual worm, is still wanting to complete the chain of evidence; and it may turn out that a natural expulsion of the cocoons by the host is a necessary provision to this end. The immature females in the most advanced stage prior to impregnation display large numbers of ovarian ova. I believe, however, that all the final stages of growth occur within the bowel of the

equine bearer. If this be so, the following conclusions, partly based on analogy, cannot be far from embracing the whole truth:—(1) The eggs are expelled from their parent in a state of fine yolk-cleavage. (2) The embryos are formed after egg-expulsion, and in a few days escape from their envelopes, undergoing a primary change of skin in moist earth during warm weather. (3) As rhabditiform Nematoids they enjoy a more or less prolonged existence, probably living many weeks in this state. (4) In all likelihood an intermediary host is unnecessary. (5) The rhabditiform larvæ are passively transferred to their equine bearer, either with cut fresh fodder, or whilst the animals are grazing. (6) Passively transferred to the intestinal canal, they thence enter the walls of the cæcum and colon, encyst themselves, and (according to Leuckart) undergo another change of skin. (7) Their presence in the intestinal walls is associated with pathological conditions which frequently prove fatal to the bearer, sometimes creating severe epizöoty. (8) Ordinarily the young worms perforate their cysts and immigrate to the lumen of the bowel, where they already afford external indications of sex (Trichonema-stage of growth). (9) They next form cocoons by the agglutination of vegetable débris within the gut, and undergo a third ecdysis attended with intestinal metamorphosis. (10) The formation of the internal sexual organs and the completion of the definitive form is accomplished within the colon of the host.

The literature of this species is as follows:—

Rudolphi.—(Proles Strongyli armati.) Entozoorum Hist. Nat. vol. i. p. 207 (1808–10).

Mehlis.—(*S. tetracanthus*) in Isis, 1831, p. 79 (quoted by Gurlt).

Gurlt.—(Vierstacheliger Pallisadenwurm.) Lehrb. d. path. Anat. der Haus-säugethiere, Bd. i. p. 355. tab. vi. figs. 23–32 (1831).

Knox.—Remarks on the lately discovered Entozoa infesting the muscles of the human body; with some observations on a similar animal found beneath the intestinal membrane of the horse. Edinb. Med. & Surg. Journ. vol. xlvi. p. 92 (1836).

Dick.—(Worms at different stages of growth.) Quoted by Dr. Knox.

Miescher.—Bericht üb. d. Verhandl. d. nat. Gesellsch. in Basel, Bd. iii. p. 5; Ann. d. Sci. Nat. tom. x. p. 191 (1838); and Wiegm. Arch. f. Naturg. 1839, 5 Jahrg. Bd. ii. p. 159.

Dujardin.—(*Sclerostoma quadridentatum*) Hist. Nat. des Helm. 1845, p. 258.

Diesing.—(*Sclerostomum tetracanthum*) Syst. Helm. vol. ii. p. 305 (*Nematoideum Equi Caballi*), p. 332 (1851).

Ercolani.—Giorn. d. Vet. 1852, t. i. p. 317 (quoted by Leuckart).

MOLIN.—(*Cyathostomum tetracanthum*) Il sottard. degli Acrofalli, 1860, pp. 453–455, tav. xxv. figs. 5, 6.

COLIN.—Mém. sur le développ. et les migrations des *Sclerostoma*, 1864 (quoted by Leuckart).

VARNELL.—(Entozoa in various stages of growth.) The Veterinarian for 1864, pp. 202 and 265.

LITTLER.—(Extremely small Ascarides.) Quoted by Varnell, as above, 1864.

SCHNEIDER.—Monog. d. Nemat., p. 134, tab. viii. figs. 7, 8 (1866).

KRABBE.—Husdyrenes Involdsorme, p. 17; Aftryk af Tidsskr. for Veterin., 1872.

COBBOLD.—Observations on rare Parasites in the Horse. The Veterinarian, March 1875.

——. Further remarks on rare Parasites from the Horse. *Ibid.* May 1874.

——. Fatal epidemics affecting Ponies. *Ibid.* June 1874; also in 'The Field' for April 25, 1874.

——. Epizöoty in the Horse, more especially in relation to the ravages produced by the four-spined Strongyle. The Veterinarian, April 1875.

——. Parasites of the Horse. (Note on specimens of *S. tetracanthus.*) *Ibid.* March 1876.

——. 'Parasites' (of Solidungula). London, 1879, p. 374 et seq. (with figs.).

LEUCKART.—Die menschl. Par., Bd. ii. 1876, p. 445 (with fig.).

SONSINO.—On the Entozoa of the Horse in relation to the late Egyptian equine plague. The Veterinarian, March 1877.

LINSTOW, O. VON.—Compend. d. Helm., p. 56–7 (1878).

DESCRIPTION OF PLATE XXXVI.

Fig. 1. Head and neck of *Strongylus Arnfieldi*. Male. × 65 diam.

2. Tail and lower part of the body. Female. × 65 diam.

3. Front view of the same.

4. Tail and lower part of the body. Male. × 65 diam.

5. Tail of the same, seen from behind. × 180 diam.

6. Plan of the expanded hood and rays, seen from behind.

7. Egg of *Strongylus Arnfieldi* with contained embryo. × 200 diam.

8. Head and neck of the embryo. × 400 diam.

9. Tail of the same, × 400 diam., with (x) appendage separately drawn, × 1000 diam.

10. Head and neck of *Strongylus tetracanthus*. Mature male. Highly magnified.

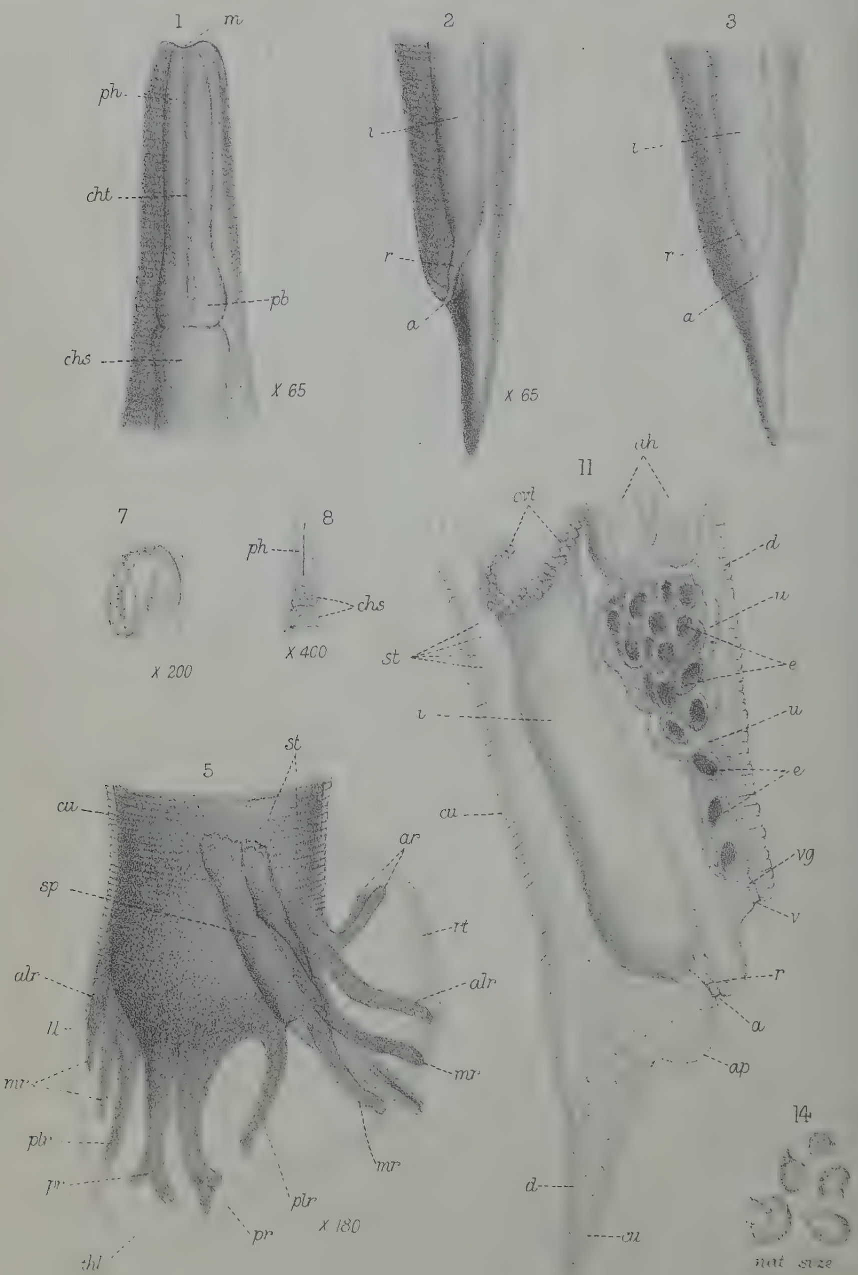
11. Tail of the same species. Female. Highly magnified.

12. Portion of the intestine of a colt, showing cysts beneath the mucous membrane, each containing a worm. Slightly enlarged.

13. One of the cysts containing a larva of *Strongylus tetracanthus* in the Trichonema-stage. × 30 diam.

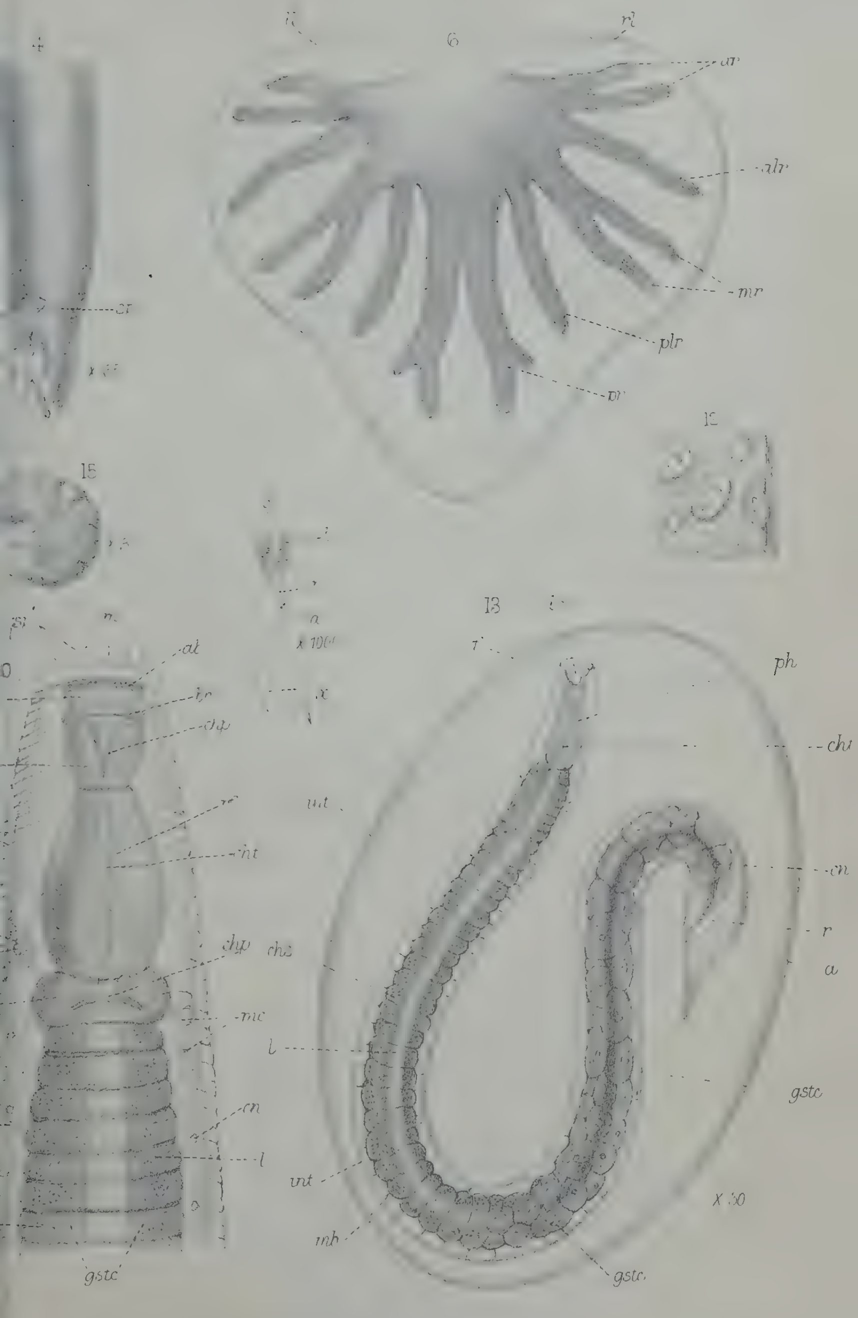
14. Group of cocoons or fæcal pellets containing immature worms. Natural size.

T.S.Cobbold ad.nat.del.



Berjeau & Iterson lith.

1–9. STRONGYLUS ARNFIE



10–15. S. TETRACANTHUS.

Mintern imp.

Fig. 15. One of the cocoons, showing a protruding larva which is undergoing ecdysis. Part of the old skin (x) is retained above the tail. × 3 diam.

m, mouth; *sp*, spines; *bc*, buccal cup; *br*, buccal ring; *f*, funnel; *db*, dental bristles (position of); *ph*, pharynx; *rf*, radial fibres; *ab*, anterior bulb; *pb*, posterior bulb; *chp*, chitinous plates; *cht*, chitinous cylinder; *cst*, chyle stomach; *l*, lumen of mid gut; *a*, anus; *ap*, anal prominence; *i*, intestine; *r*, rectum; *gstc*, gastro-intestinal gland-cells; *mb*, muscular bands; *mc*, muscle-cells; *c*, corpuscles; *sp*, spicules; *h*, hood; *rl*, right lobe; *ll*, left lobe; *thl*, third or middle lobe; *ar*, anterior ray; *alr*, antero-lateral ray; *mr*, middle ray; *plr*, postero-lateral ray; *pr*, posterior ray; *v*, vulva; *vg*, vagina; *e*, eggs; *int*, integument; *cu*, cuticle; *d*, dermis; *st*, striæ; *cgc*, colossal gland-cell; *cn*, cell-nucleus; *u*, uterus; *uh*, uterine horns; *ovt*, ovarian tube.

Notes on Entomostraca collected by Mr. A. Haly in Ceylon.

By George Stewardson Brady, M.D., F.R.S., F.L.S., C.M.Z.S.

[Read 17th December, 1885.]

(Plates XXXVII.–XL.)

The Entomostraca here described belong to two sets of gatherings, one from fresh, the other from salt, water. The freshwater species were all taken at Colombo, but of the exact localities no record has been forwarded to me. The marine species, described in Part II. of this paper, were dredged in a depth of 2 fathoms off Calpentyn, in the Gulf of Manaar. For all of them I am indebted to the kindness of Mr. A. Haly, of the Colombo Museum.

Of the freshwater species, especially the Copepoda and Cladocera, the chief interest lies in their very near approach to well-known European species,—all the genera being represented in Northern Europe by species very closely resembling those of Ceylon. Amongst the Ostracoda is a curious form, for which I have thought it right to propose a new generic name, *Cyprinotus*. And, lastly, I have been able to add a little to the descriptions already given by Dr. Baird of two species, *Cypris cylindrica* (*C. Malcolmsoni*) and *C.* (*Chlamydotheca*) *subglobosa*.

The marine species are scarcely of so much interest. They include no new genus, but several new species are described, and some which have hitherto been only imperfectly known are, I think, placed on a more secure footing.

Part I.—*Fresh-water Species.*

Subclass ENTOMOSTRACA.

Legion *BRANCHIOPODA.*

Order PHYLLOPODA.

Family Limnadidæ.

Genus Limnadia, *Brongniart.*

Limnadia Hislopi (*Baird*). (Plate XXXVII. figs. 1–3.)

Estheria Hislopi, *Baird, Proc. Zool. Soc.* 1869 (Annulosa), pl. 63. fig. 1.

The Colombo specimens have been kindly compared for me by my brother, Mr. H. B. Brady, F.R.S., with the type specimens in the British Museum; there seems to be no appreciable difference except in the point of size, the types being somewhat larger. The Ceylon examples, however, are probably young ones, the shell being simply granular and showing no concentric ribs except in the largest of the lot, where the ridges are faintly visible. The smaller antennæ are distinctly club-shaped, a character which refers the animal to *Limnadia* rather than *Estheria.* Length $\frac{8}{100}$ to $\frac{12}{100}$ of an inch (2–3 millim.).

Order CLADOCERA.

Family Daphnidæ.

Genus Moina, *Baird.*

Moina submucronata, n. sp. (Plate XXXVII. figs. 4, 5.)

The cervical constriction is not nearly so deep as in the published figures of other *Moinæ*; the head is upright and subtriangular; the dorsal margin of the carapace almost straight, the ventral strongly arched, and forming at its junction with the posterior margin a more or less distinctly mucronate angle; posterior extremity truncated, but well rounded at the dorsal angle. Length (exclusive of antennæ) $\frac{1}{25}$ of an inch (1 millim.).

Family Lyncodaphnidæ.

Genus Ilyocryptus, *Sars.*

Ilyocryptus Halyi, n. sp. (Plate XXXVII. figs. 6–9.)

The head is obtusely angular at the apex, not rounded;

posterior antennæ large, but not so excessively thick and muscular as in *I. sordidus*. Postabdomen consisting of two laminæ, each of which bears a long, slender, terminal claw, and behind this a series of twelve marginal curved spines, six long and six short alternately; following close upon these, and immediately behind the anal orifice, is another series of about twelve equal, but still shorter, spines, then a sinus corresponding with the intestinal outlet; between this and the anterior angle of the limb is another row of six larger and more widely separated spines, followed by a couple of long slender setæ. The carapace is marked within the posterior and ventral margins by several concentric lines, probably corresponding with periods of growth, and perhaps indicating also that the shell of this species does not undergo the normal periodical exuviation; the posterior and ventral margins of the carapace are densely fringed with plumose hairs, long on the ventral, but becoming gradually shorter towards the dorsal margin. The four-jointed branch of the large antenna has imperfectly marked divisions in the centre of each joint (fig. 7), giving it the appearance, under a low power, of being divided into eight joints. Length $\frac{1}{26}$ of an inch (·98 millim.).

Genus Macrothrix, *Baird.*

Macrothrix triserialis, n. sp. (Plate XXXVII. figs. 16–20.)

The carapace seen laterally is subtriangular or heart-shaped, the posterior extremity tapered, angular and mucronate; the head is slightly produced into a triangular rostrum, from which depends the strap-like anterior antenna, serrated on its anterior margin and ending in three small setæ. The free margins of the carapace are serrated with short stout teeth, which run more or less distinctly in series of three (fig. 20), the intervals bearing long slender hairs. Length $\frac{1}{24}$ of an inch (1·05 millim.).

Family Lyncæidæ.

Genus Alona, *Baird.*

Alona acanthocercoides (*Fischer*). (Plate XXXVIII. fig. 1.)

Lynceus acanthocercoides, *Fischer, Leydig, Norman, and Brady.*
Eurycercus acanthocercoides, *Schödler.*
Alona acanthocercoides, *P. E. Müller.*
Leydigia acanthocercoides, *Kurz, Herrick.*

Order COPEPODA.

Family Calanidæ.

Genus Diaptomus, *Westwood.*

Diaptomus orientalis, n. sp. (Plate XXXVII. figs. 21–26.)

Posterior margin of the last thoracic segment forming on each side a bidentate process, the outer angle of which is much larger than the inner. Abdomen of the female two-, of the male four-jointed. Anterior antenna 25-jointed, and as long as the cephalothorax; that of the right side in the male differs only slightly from the same organ in *D. castor*; the apical process of the twenty-third joint is, however, larger. The inner branch of the fifth foot of the female is considerably longer than in *D. castor*, and in the male the foot of each side consists only of a single branch. Length $\frac{1}{20}$ of an inch (1·3 millim.).

Family Cyclopidæ.

Genus Cyclops, *Müller.*

Cyclops ——, sp. (Plate XXXVIII. figs. 2–4.)

I figure the anterior antenna, fifth foot, and furca of a species which occurs abundantly in Mr. Haly's gatherings. It seems to be so nearly allied to several described species that, for the present, I do not assign it any specific name. The anterior antennæ are 17-jointed, and reach to the extremity of the second body-segment; the tail-segments about thrice as long as broad.

Family Harpacticidæ.

Genus Attheyella, *G. S. Brady.*

Attheyella cingalensis, n. sp. (Plate XXXVII. figs. 10–15.)

This species is very similar to *A. spinosa*, but the fifth pair of feet are different, the inner branch of the first pair is three-jointed, those of the second and third pairs are two-jointed, the first joint very small; of the fourth pair one-jointed. Length of the animal $\frac{1}{50}$ of an inch (·5 millim.).

Legion *LOPHYROPODA.*

Order OSTRACODA.

Family CYPRIDIDÆ.

Genus CYPRIS, *Müller.*

CYPRIS MALCOLMSONI, *G. S. Brady.* (Plate XXXVIII. figs. 5–7.)

Cypris cylindrica, *Baird, Proc. Zool. Soc.* 1859, pl. 63. fig. 3.

I have been enabled to compare the Ceylon specimens with some from the Nagpur gathering, described by Dr. Baird, for which specimens, as well as for some of the fossil *C. cylindrica* collected by Dr. Malcolmson, I am indebted to my friend Professor T. Rupert Jones. The two series are undoubtedly identical; but I learn from my brother, Mr. H. B. Brady, that those preserved in the British Museum are much larger,—probably Baird's variety *major* *.

The following brief description is drawn up from the Ceylon specimens:—

Shell elongated, subreniform, rather higher behind than in front; in lateral view the extremities are rounded, dorsum forming a flattened arch, almost or quite straight in the middle; ventral margin slightly sinuated in front of the middle; greatest height equal to rather more than one third of the length: seen from above, the outline is an extremely compressed oval, tapered towards the front; extremities subacuminate; width equal to more than one fourth of the length. Surface smooth and polished, mottled green. Length $\frac{1}{12}$ of an inch (2·1 millim.). The terminal claws, as well as the posterior portion of the margin of the postabdominal rami, are beautifully pectinated (Plate XXXVIII. fig. 5); in other respects I have not found that the animal differs from a normal *Cypris.*

The shell has been well figured by Dr. Baird (*loc. cit.*). The species would seem to be abundant both at Colombo and at Nagpur, from which last-named locality Dr. Baird's specimens came.

* I cannot, however, follow Dr. Baird in identifying the recent specimens with Sowerby's *C. cylindrica*, which, though very similar in general character, is smaller, higher in proportion to its length, considerably more tumid, and more rounded in its lateral contour.

CYPRIS MONILIFERA, n. sp. (Plate XXXIX. figs. 10–12.)

Shell reniform: seen from the side the extremities are rounded and nearly equal, the posterior, however, somewhat flattened; dorsal margin boldly arched and almost gibbous in the middle, ventral deeply sinuated in the middle; height equal to more than half the length: seen from above, ovate, widest in the middle, tapered towards the anterior extremity, which is rounded, though much narrower than the posterior. On each valve a little within, and parallel to, the posterior margin, is a crescentic row of about six bead-like tubercles; otherwise the surface of the shell is quite smooth. Colour green. Length $\frac{1}{33}$ of an inch (·77 millim.).

I have met with one specimen only of this species.

CYPRIS LUXATA, n. sp. (Plate XXXVIII. figs. 8–11.)

Valves very unequal; the left much larger than the right, which it overlaps at all points, except the anterior portion of the dorsum: seen laterally, the shape is subreniform, of nearly equal height throughout; anterior extremity somewhat obliquely rounded, posterior oblique, subtruncate; dorsal margin very slightly arched, rather abruptly rounded off behind, ventral almost straight: seen from above, the outline is unequally ovate, the right side being much smaller than the left. Height equal to at least half, width equal to rather more than one third of the length. Surface of the shell smooth. Colour greenish-brown. Length $\frac{1}{26}$ of an inch (·98 millim.).

CYPRIS PURPURASCENS, n. sp. (Plate XXXVIII. figs. 12–14.)

Shell elongated, subovate, rather tumid: seen laterally, the outline is subelliptical with rounded extremities, the anterior extremity broad and evenly rounded, posterior somewhat produced and narrowed; dorsal margin well and evenly arched, ventral nearly straight; greatest height situated in the middle and equal to nearly half the length: seen from above, ovate, widest in the middle; at least twice as long as broad; right valve smaller than the left; extremities equal, subacuminate, abruptly tapered. Surface of the shell smooth. Colour creamy white, or yellowish and clouded with purple. Length $\frac{1}{25}$ of an inch (1 millim.).

This species was the most abundant of the Ostracoda sent to me by Mr. Haly.

Cypris Halyi, n. sp. (Plate XXXVIII. figs. 15–17.)

Shell, seen laterally, subtriangular, higher in front than behind; height equal to more than half the length; anterior extremity broad and evenly rounded, posterior also rounded, but much narrower; dorsal margin elevated and obtusely angulated in front of the middle, thence sloping steeply backwards, but more gently towards the front; ventral margin slightly convex: seen from above the outline is almost boat-shaped, widest just in front of the middle, tapering sharply to an acuminate extremity in front; posterior extremity wider, and showing on each valve a minute spine; width and height equal. Shell smooth, sculptured in a manner precisely like that of the European species *C. tessellata*, Fischer. Colour pale olive, with three or four indistinct transverse bands of a darker hue. Length $\frac{1}{33}$ of an inch (·77 millim.).

It is curious that this species, so like *C. tessellata* in surface-markings, should likewise present the same peculiarities of form. It must, however, be borne in mind that a similar style of sculpture is met with in the young of some species (*C. obliqua*, Brady, *C. affinis*?, Fischer) and disappears, wholly or partially, in advanced life. It is therefore just possible that *C. Halyi* may be the young form of some other species. Only one specimen was observed.

Cypris tenuicauda, n. sp. (Plate XXXVIII. figs. 18–20.)

Shell, seen laterally, reniform, about once and a half as long as broad, highest in the middle; extremities equal and well rounded; dorsal margin evenly arched, ventral slightly sinuated: seen from above the outline is ovate, widest behind, and gradually tapered towards the front; extremities rounded, anterior very narrow, almost acuminate, posterior very wide. Surface of the shell smooth, but not polished, and sometimes showing a few very short rigid hairs. Colour milky-white. Length $\frac{1}{28}$ of an inch (·88 millim.). The postabdominal rami are unusually slender; the terminal claws very long.

Cypris furfuracea, n. sp. (Plate XXXVIII. figs. 21–23 *a*.)

Shell tumid, subreniform: seen laterally, the extremities are broadly rounded, dorsal margin very boldly arched, sloping more gradually towards the front, ventral almost straight; greatest height in the middle, and equal to about two thirds of the length: seen from above, subelliptical, with rounded, obtuse extremities, somewhat narrower in front than behind; rather

more than twice as long as broad. Surface smooth, opaque; yellowish brown, with transparent patches. Length $\frac{1}{45}$ of an inch (·55 millim.).

Genus CHLAMYDOTHECA, *De Saussure.*

(Chlamydotheca, *De Saussure*; ? Cypridea *, *Bosquet.*)

CHLAMYDOTHECA SUBGLOBOSA (*Sowerby*, *fide Baird*). (Plate XXXVIII. figs. 24–27 *a.*)

Cypris subglobosa, *Baird, Proc. Zool. Soc.* 1859, pl. 63. fig. 2.

Shell subglobular, tumid: seen from the side, subovate, highest in the middle, height equal to quite half the length, anterior extremity obliquely rounded, posterior narrowed and somewhat produced, rounded off; dorsal margin evenly arched, sloping more steeply behind than in front, slightly sinuated toward either extremity; ventral margin almost straight: seen from above the outline forms almost a circle, with the anterior and posterior ends produced to acute angles, the anterior much the more attenuated of the two; width equal to three fourths of the length. The two valves are nearly equal, but the right is much more irregular and more angulated than the left; its anterior portion forms a sort of outgrowth, which is separated from the rest of the valve by a strongly marked sulcus; the ventral margin is deeply and abruptly sinuated near the middle, the posterior extremity forming a produced and somewhat angulated beak and bearing a series of more or less distinct serratures; similar teeth are found also at both

* The following definition of the genus *Cypridea* is given by Professor T. Rupert Jones, F.R.S., in a paper, "On the Ostracoda of the Purbeck Formation" (Quarterly Journal of the Geological Society, August 1885, p. 336):—

"Carapace-valves subtriangular, obovate, or ovate-oblong; convex in the middle; broad (high) at the anterior third, narrower behind; one or both ends obliquely rounded; somewhat compressed anteriorly; notched at the antero-ventral angle, behind a small beak-like process; sometimes having only a slight indentation below, and behind a thickening of the antero-ventral angle; sometimes this is traceable only by a curvature of the edge inside. Edge-view more or less narrow-ovate; end-view subovate. Surface punctate, sometimes almost smooth, often tuberculate; tubercles small or large, variously disposed. The hinge-margin is definitely straight along the middle third or more of the dorsal edge, with the hinge-angles more or less defined, and is oblique to the main axis of the valve. The left valve is the largest, and receives the dorsal edge and a straight ridge of the other valve in grooves on its dorsal and ventral contact-margins, the outer edge of the ventral margin of the left valve overlapping that of the right valve. The ridges and furrows or ledges of contact vary in intensity in different individuals."

extremities of the left valve. The end view of the shell is triangular. Surface smooth, marked with large, closely-set punctures. Colour green. Postabdominal rami extremely slender. Length $\frac{1}{15}$ of an inch (1·6 millim.).

This and *Cypris cylindrica* are the two most abundant species in Mr. Haly's gatherings.

Between this species and the published drawings and descriptions of Bosquet's genus *Cypridea* there are some not unimportant discrepancies, particularly the straight hinge-margin and ovate end-view of *Cypridea*. Moreover it would seem that the peculiar notch and produced beak of *Cypridea* are quite apparent when the two valves are in contact, which is scarcely the case in *C. subglobosa*. Indeed this character was not at all noticed by Dr. Baird. On the whole, though *C. subglobosa* must be recognized as forming a most interesting link between *Cypris* and *Cypridea*, we are perhaps scarcely warranted in referring it definitely to the latter genus. In the soft parts of the animal I cannot, after careful examination, discover anything to distinguish it from *Cypris*.

De Saussure's subgenus *Chlamydotheca** is founded upon a species presenting exactly the peculiar shell-formation of *C. subglobosa*; and as a matter of convenience it seems desirable to adopt the name either in a generic or subgeneric sense. Sir John Lubbock also has described a species, *Cypris brasiliensis*, belonging to the same group†.

The fossil specimens described by Mr. Sowerby, some of which Professor T. Rupert Jones has kindly allowed me to examine, are, I think, undoubtedly identical with Dr. Baird's Nagpur specimens and with those collected by Mr. Haly at Colombo. They are wonderfully well-preserved, and show the same sculpture as the recent form, the most important difference being that, when viewed from above, the anterior extremity is (in some cases at least) produced to a longer and more attenuated point.

Genus Cyprinotus, nov. gen.

Like *Cypris* except that the valves are very unequal, that of

* *Cypris* (*Chlamydotheca*) *azteca*. Mémoire sur divers Crustacés nouveaux des Antilles et du Mexique, par M. Henri de Saussure (Mémoires de la Société de Physique et d'Histoire Naturelle de Genève, 1858).

† "On the Freshwater Entomostraca of South America" (Trans. Entom. Soc. Lond. iii. 1855).

the right side being extremely gibbous and overlapping the left in the middle of the dorsal margin. Hinge-margins without teeth.

CYPRINOTUS CINGALENSIS, n. sp. (Plate XXXVIII. figs. 28–30.)

Shell, seen laterally, subtriangular, greatest height situated in the middle and equal to nearly two thirds of the length; anterior extremity obliquely rounded and somewhat narrowed, posterior broad, rounded, but somewhat flattened; dorsal margin greatly elevated, the highest point being just a little behind the middle, thence sloping steeply and with a distinct sinuation towards both extremities, ventral margin gently convex: seen from above, the outline is ovate, compressed and pointed in front, rounded behind, twice as long as broad, the greatest width in the middle; the dorsal surface marked in the middle by a deep longitudinal furrow. The internal surfaces of both valves show large semilunar marginal flanges before and behind; the hinge-margins are simple and devoid of teeth; the left valve is finely hirsute on the anterior half of the ventral margin, which, however, bears no teeth, while that of the right valve is denticulated throughout its whole length, the teeth becoming gradually more pronounced towards the posterior extremity. The surface of the shell is smooth, and marked throughout with closely-set impressed puncta. Colour clouded gray, with diagonal bands of green on the posterior half. The soft parts of the animal are in all respects, so far as I have been able to ascertain, as in *Cypris*. Length $\frac{1}{18}$ of an inch (1·4 millim.).

Four or five specimens were seen, all of them, I think, males.

The validity of genera founded solely on peculiarities of shell-structure may often be reasonably doubted, but in this case the divergence from the normal *Cypris* type is so marked as to make the separation unavoidable. Moreover some of the Ostracod genera, notably *Cypris* and *Cythere*, are becoming so unwieldy by reason of the large number of species referred to them, that some subdivision either into genera or subgenera is, or soon will be, a matter of necessity. And it is to be remembered that characters derived from the shell, in an important palæontological group like the Ostracoda, are valuable as being the only ones accessible to students of fossils.

Genus Cypridopsis, *G. S. Brady.*

Cypridopsis globosa, n. sp. (Plate XXXIX. figs. 1–3.)

Shell very tumid, almost globose: seen from the side, the outline is very broadly subovate, the greatest height in the middle, and equal to nearly three-fourths of the length; extremities broadly rounded; dorsal margin excessively arched, ventral slightly convex: seen from above, very broadly and regularly ovate, widest in the middle, width and height equal, extremities rounded, the anterior subacuminate. Surface marked with closely set impressed puncta and densely clothed with short, rigid hairs. Colour greyish white. Length $\frac{1}{43}$ of an inch (·57 millim.).

This species is very like some unbanded forms of the European *C. vidua*, but the carapace is much more nearly globose, the height and width being greater in proportion to the length.

Cypridopsis marmorata, n. sp. (Plate XXXIX. figs. 7–9).

Shell very tumid, ovate, width slightly greater than the height: seen from the side elongated, subreniform, highest in the middle, height equal to about two-thirds of the length; anterior extremity narrowed, obliquely rounded; posterior well and broadly rounded; dorsal margin broadly arched, somewhat angulated in the middle, ventral almost straight: seen from above, ovate, widest in the middle, tapering and acuminate in front, broadly rounded behind. The end-view is almost circular, the width being slightly in excess of the height. Surface of the shell smooth. Colour greyish or yellowish white, marked with irregular wavy bands of black. Length $\frac{1}{43}$ of an inch (·57 millim.).

Like the preceding, this comes very near to *C. vidua*, and in shape is even more like that species, but the surface-markings are much less regular in disposition, the lateral view is rather more elongated, and the shell is destitute of hairs, so far as can be seen in dried specimens.

Part II.—*Marine Species.*

Genus Pontocypris, *G. O. Sars.*

Pontocypris nitida, n. sp. (Plate XXXIX. figs. 4–6.)

Shell, seen laterally, subtriangular, nearly twice as long as broad, highest a little in front of the middle; anterior extremity broadly

and evenly rounded, posterior attenuated and subacuminate; dorsal margin strongly arched and almost angular at its highest point, thence sloping evenly and with a steep curve in both directions, ventral slightly sinuated: seen from above, the outline is obovate, twice and a half as long as broad, broadest near the front, extremities obtusely pointed. Surface of the valves smooth and shining, milk-white, bearing numerous short, rigid, hair-like papillæ evenly distributed over the whole shell. Length $\frac{1}{38}$ of an inch (·66 millim.).

One specimen only seen.

This species is very like *P. trigonella*, Sars, but is smaller, higher in proportion to its length, and more attenuated behind, while the surface is more polished, and instead of adpressed hairs has numerous minute processes of the true nature of which I am not quite certain, as they assume different appearances under different conditions of illumination; I think, however, that they are very minute setæ. *P. Davisoni*, Brady, is also nearly allied, but is more tumid and generally rounder in its outlines, besides being destitute of any special surface-ornament.

Genus Bairdia, *MCoy*.

Bairdia tenera, n. sp. (Plate XXXIX. figs. 13–15.)

Shell, seen laterally, subreniform, highest in the middle; height equal to fully half the length; anterior extremity obliquely rounded, posterior produced into a not very prominent rounded beak; dorsal margin boldly and evenly arched, ventral sinuated in the middle: seen from above, compressed, lozenge-shaped, nearly thrice as long as broad, widest in the middle, thence tapering evenly to the extremities, which are subacuminate. Surface smooth, slightly granular, and bearing a few excessively short hairs. Length $\frac{1}{35}$ of an inch (·75 millim.).

One specimen only was seen. The specimen has the appearance of an adult shell, but it is nevertheless quite possible that it may not be fully grown. Even so it can scarcely be referable to any described species.

Genus Aglaia, *G. S. Brady*.

Aglaia (?) acuminata, n. sp. (Plate XL. figs. 1–3.)

Shell elongated, compressed, reniform, higher behind than in front: seen from the side it is nearly thrice as long as broad;

extremities well rounded, the posterior rather the wider of the two; dorsal margin almost straight, ventral deeply sinuated in front of the middle: seen from above, the outline is compressed, ovate, much tapered, and sharply acuminate in front, rounded behind, thrice as long as broad. Surface of the valves smooth, marked with numerous large circular papillæ. Length $\frac{1}{55}$ of an inch (·46 millim.).

One specimen only of this species was observed.

Family Cytheridæ.

Genus Cythere, *Müller*.

Cythere truncatula, n. sp. (Plate XXXIX. figs. 25–28.)

Carapace of the *female*, seen from the side, subquadrangular, rather higher in front than behind, height equal to more than half the length; anterior extremity broadly and rather obliquely rounded, posterior narrowed and abruptly truncated; dorsal margin straight in the middle, slightly curved towards the extremities, ventral sinuated in the middle and bent upwards behind: seen from above, ovate, twice as long as broad, widest behind the middle; posterior extremity moderately wide, rounded, anterior obtuse, subtruncate. Surface of the valves marked throughout with large, closely-set, and deep angular pits. Length $\frac{1}{50}$ of an inch (·5 millim.). The shell of the *male* differs only in its more slender proportions, the height and width being less and the length rather greater.

This is an abundant species, and much resembles the European *C. villosa*, Sars, in its sculpture, though not in the shape of the shell.

Cythere fabacea, n. sp. (Plate XL. figs. 4–6.)

Carapace of the *female*, seen from the side, somewhat siliquose, the postero-ventral angle being somewhat produced; extremities obliquely rounded and nearly equal, the posterior sloping steeply and with only a slight curvature; dorsal margin evenly arched and forming with the extremities one continuous curve, ventral sinuated in the middle; the antero-ventral angle is crenulated with about a dozen notches: seen from above, the outline is ovate, twice as long as broad, the greatest width in the middle; extremities rounded, obtuse. Surface smooth, marked with numerous large and closely-set subrotund pits. Length $\frac{1}{45}$ of an

inch (·56 millim.). The *male* is rather larger and more slender in its proportions, and in many cases the sides of the shell show two median transverse furrows.

This, like the preceding, occurred in considerable numbers in Mr. Haly's gathering.

CYTHERE RUPERTI, n. sp. (Plate XXXIX. figs. 16–18.)

? Cythere cancellata, in part, *Brady, Report on the Ostracoda of the 'Challenger' Expedition,* p. 73, pl. xiv. figs. 9, *d, e.*

Shell, seen laterally, elongated, subquadrate, very slightly higher in front than behind; height equal to somewhat less than half the length; anterior extremity obliquely rounded, bordered below the middle and round the ventral angle with a series of about twelve short, blunt, and equal teeth; posterior obliquely truncated above the middle, rounded and finely denticulated below; dorsal margin nearly straight, sloping slightly from before backward, ventral gently sinuated in the middle: seen from above, ovate, more than twice as long as broad, obtusely pointed and emarginate in front, rounded behind and produced into a wide central mucro. The valves are bordered before and behind with a flattened lip or flange, which extends partially to the dorsal and ventral margins. The surface is sculptured with distinct rounded pits in young and middle-aged specimens, but in old ones these tend to run into wavy transverse furrows; there is usually also a large central tubercle with a deep sulcus in front and behind. Length $\frac{1}{30}$ of an inch (·85 millim.).

This is a pretty and well-marked species which I have pleasure in naming after my friend Professor T. Rupert Jones, F.R.S. In the Calpentyn dredging it occurs abundantly, and in many stages of growth. The ornamentation of the shell is almost exactly as in *C. fabacea*, but its general contour is very different, the differences being well marked at all ages.

CYTHERE CANCELLATA, *G. S. Brady.*

Cythere cancellata, *Brady, Les Fonds de la Mer* (1868); *Report on the Ostracoda of the 'Challenger' Expedition*, p. 73 (1880).

The type specimens of this species were from Java, those of the 'Challenger' Expedition from Booby Island and Tongatabu. Two figures (plate xiv. fig. 9, *d*, *e*) given in the 'Challenger' Report are referable, I think, not to *C. cancellata*, but to the species here described as *Cythere Ruperti*; of this, however—the specimens not being at hand—I cannot be quite sure.

CYTHERE SUBCUNEATA, n. sp. (Plate XXXIX. figs. 29–30.)

Shell, seen from the side, elongated, subcuneiform, higher in front than behind; height scarcely equal to half the length; anterior extremity very obliquely rounded, posterior narrowed, obliquely truncated, and slightly produced at the ventral angle; dorsal margin elevated at the anterior third, thence sloping with a slightly sinuous curve backwards, steeply and with a regular curve to the front; ventral margin gently sinuated: seen from above, the outline is regularly ovate, widest in the middle, more than twice as long as broad; extremities rather wide, subacuminate. Shell-surface marked with numerous shallow circular pits with rounded papillæ in the interspaces, the pits coalescing into furrows on the anterior and ventral surfaces. Length $\frac{1}{35}$ of an inch (·75 millim.).

This species is represented in the Calpentyn gathering by several specimens.

CYTHERE CORALLOIDES, n. sp. (Plate XXXIX. figs. 19–22.)

Shell, seen laterally, subquadrate, twice as long as broad, greatest height situated near the front; anterior extremity obliquely rounded, its lower half bordered with short equal teeth, posterior truncated, slightly emarginate above the middle but not toothed; dorsal margin forming an elevated angle over the anterior hinge-tubercle (which is large and glistening), thence sloping in an irregular sinuous line to the posterior extremity; ventral margin nearly straight: seen from above, broadly ovate, widest behind the middle, scarcely twice as long as broad; posterior extremity wide and rounded, with a broad median prominence, anterior narrow, subtruncate. Surface of the shell marked everywhere with coarse angular impressions, and having one or more indistinct, flexuous, longitudinal ribs on the lateral aspect of the valves. Length $\frac{1}{33}$ of an inch (·77 millim.).

There are two forms of this species:—one, from which the description has been drawn up, tumid and rounded in its outlines, the other (probably the male) smaller, more slender, and angular. Both of these forms are here figured. If the more slender form be really the male, it is probably not full-grown, inasmuch as the males of *Cythere* are usually longer than the females. All these angular specimens are, however, in this case smaller than the rounded ones.

Cythere papuensis, *G. S. Brady.*

Cythere papuensis, *Brady, Report on the Ostracoda of the 'Challenger' Expedition,* p. 95, pl. xxv. figs. 5 *a–d.*

Cythere Goujoni, *G. S. Brady.*

Cythere Goujoni, *Brady, Les Fonds de la Mer,* tom. i. p. 78, pl. x. figs. 9, 10; *Report on the Ostracoda of the 'Challenger' Expedition,* p. 96, pl. xxv. figs. 7 *a–g.*

Cythere Stimpsoni, *G. S. Brady.* (Plate XXXIX. figs. 23, 24.)

Cythere Stimpsoni, *Brady, Les Fonds de la Mer,* t. i. p. 78, pl. x. figs. 7, 8.

Shell, seen from the side, quadrangular, somewhat higher in front than behind, height equal to more than half the length; anterior extremity obliquely rounded, and bearing numerous small teeth, posterior rectangularly truncated, produced abruptly below the middle, the produced portion divided into four or five stout teeth, which project directly backward; dorsal margin straight, forming an elevated angle over the hinge-tubercle, ventral straight, curved upwards at the posterior extremity: seen from above, oblong, subhastate, widest behind the middle, twice as long as broad; anterior extremity obtuse, with two mucronate processes, posterior wide, truncated, with a broad dentated central projection. Surface irregularly tuberculated and pitted, and having on the lateral aspect of the valves three prominent, compressed, flexuous, longitudinal ribs, one of these being coincident with the dorsal margin, and ending abruptly a little in front of the middle; hinge-tubercles prominent and glistening. Ventral surface quite flat. Length $\frac{1}{40}$ of an inch (·65 millim.).

Two specimens only of this species were seen. The type specimen, sent to me by M. le Marquis de Folin, passed out of my possession after being described, and the figures given in 'Les Fonds de la Mer' are by no means satisfactory. I can scarcely doubt, however, that these Ceylon shells belong to the same species, and that the Mediterranean form referred by me to *C. Stimpsoni* (Ann. & Mag. Nat. Hist. *passim*) ought to be renamed as a distinct species. I therefore propose to call it after my friend the Rev. Dr. A. M. Norman, *Cythere Normaniana.*

Cythere Darwini, *G. S. Brady.*

Cythere Darwini, *Brady, Les Fonds de la Mer,* tom. i. p. 71, pl. viii. figs. 17, 18; *Report on the Ostracoda of the 'Challenger' Expedition,* p. 97, pl. xxv. figs. 2 *a–g.*

CYTHERE MELOBESIOIDES, *G. S. Brady.*

Cythere melobesioides, *Brady, Les Fonds de la Mer,* tom. i. p. 162, pl. xix. figs. 10, 11; *Report on the Ostracoda of the 'Challenger' Expedition,* p. 108, pl. xviii. figs. 1 *a, g.*

Cythere nodulifera, *Brady, Les Fonds de la Mer,* tom. i. p. 163, pl. xix. figs. 24, 25.

CYTHERE LACTEA, *G. S. Brady.*

Cythere lactea, *Brady, Trans. Zool. Soc.* (1865) vol. v. p. 377, pl. lx. figs. 3 *a–c*; *Report on the Ostracoda of the 'Challenger' Expedition,* p. 91, pl. xxii. figs. 1 *a–d.*

CYTHERE BIMAMILLATA, n. sp. (Plate XL. figs. 10–12.)

Carapace very tumid, ventricose: seen from the side, quadrangular, height equal to nearly two thirds of the length and about the same throughout; anterior extremity obliquely rounded, posterior truncated, scarcely rounded and nearly as wide as the anterior; dorsal margin almost straight, very slightly inclined from before backwards, ventral straight: seen from above, the shell is of an irregular lozenge-shape, greatest width equal to three fourths of the length, and situated near the middle, where the lateral margins form strongly projecting angles, converging sharply towards the subacute anterior extremity and scarcely at all towards the posterior, which is wide and truncated; ventral surface flattened. Shell-surface closely set with circular impressed puncta; the centre of each valve has a strongly marked irregular elevation, and the postero-dorsal angle has a similar but much smaller nodule. Length $\frac{1}{58}$ of an inch (·43 millim.).

CYTHERE LAQUEATA, n. sp. (Plate XXXIX. figs. 34–36.)

Shell, seen from the side, oblong, subovate, twice as long as high, height nearly equal throughout, or only very slightly higher in front, extremities obliquely rounded, the posterior flattened; dorsal margin almost straight, ventral slightly sinuated in the middle: seen from above, oblong, subhastate, greatest width in the middle and equal to less than half the length, tapering with a gentle curve to the broadly pointed anterior extremity; posterior extremity truncated, with a wide emarginated median prominence. Surface smooth; a small rounded tubercle in the middle of each valve, and four flexuous, not very prominent longitudinal ribs, which unite in loops in front and behind. Length $\frac{1}{30}$ of an inch (·85 millim.).

Cythere rectangularis, *G. S. Brady.* (Plate XL. figs. 7–9.)

Cythere rectangularis, *Brady, Les Fonds de la Mer*, t. i. p. 153, pl. 18. figs. 13, 14. (Not *rectangularis* (*Audei*) of 'Challenger' Report.)

Shell oblong, much compressed: seen from the side it is irregularly angular and somewhat ear-shaped, much higher in front than behind, length equal to about twice the height; anterior extremity wide and obliquely rounded, posterior narrow, obliquely truncated and deeply emarginate; dorsal margin arched, evenly curved in front, sloping steeply backwards, and deeply hollowed in front of the posterior angle, which is very prominent and almost rectangular; ventral margin deeply sinuated: seen from above, the outline is extremely irregular, about twice as long as broad, the extremities much produced, attenuated, and sharply pointed, lateral margins deeply indented at three points, the posterior indentation rectangular. Surface of the shell irregular; a strong rounded rib running parallel to and just inside the margins, but most conspicuous at the posterior and ventral edges. Length $\frac{1}{50}$ of an inch (·5 millim.).

This is the most abundant species in the Calpentyn gathering. The figure of it given in 'Les Fonds' shows very fairly the general character of the shell. The type, however, as in the case of *C. Stimpsoni*, is no longer accessible to me, and I am glad by means of this good series of specimens to be able to place the species on a more secure foundation. The synonym *rectangularis*, given in the 'Challenger' Report under *C. Audei*, must be withdrawn.

Cythere Hodgii, *G. S. Brady.*

Cythere Hodgii, *Brady, Trans. Zool. Soc.* vol. v. (1865) p. 373, pl. 59. figs. 3 *a, b*; *Report on the Ostracoda of the 'Challenger' Expedition*, p. 94, pl. xxv. figs. 1 *a–d*.

A single specimen, very closely resembling the type described in the 'Zoological Transactions,' occurred in the Calpentyn dredging. It is, however, very different from the specimens so named in the 'Challenger' Report, which, if they belong to the same species, must be very much older shells. It is probable that they should receive a fresh name; but a larger series of the Ceylon form, in different stages of growth, is requisite to settle the question.

Cythere iniqua, *G. S. Brady.* (Plate XXXIX. figs. 31–33.)

Cytherura bataviana, *Brady, Les Fonds de la Mer*, t. i. p. 65, pl. 8. figs. 7–9.
Cythere iniqua, *id. ibid.* p. 64, pl. 8. figs. 3–6.

Shell of the male, seen laterally, oblong, obliquely quadrate, of equal height throughout, height equal to half the length; anterior extremity obliquely rounded and fringed with about six small triangular teeth; posterior extremity oblique, rounded off below, bearing a short sharp spine in the middle, and usually one smaller one above, upper half of the margin obliquely truncate; dorsal margin nearly straight, ventral straight in front, curving upwards behind: seen from above, oval, with acuminate extremities, twice as long as broad, a slight angular alate prominence on each side behind the middle: end-view almost square with rounded angles, dorsal margin centrally emarginate, ventral keeled. Surface marked with a rather coarse, raised, reticulated pattern, and with two longitudinal crests, one obliquely in the middle line of the valve, the other just within the ventral margin and ending in a sharp angle behind the middle, forming, when seen from below, a slight lateral ala; there is also a deep transverse furrow across the middle of each valve. Length $\frac{1}{42}$ of an inch (·6 millim.).

This was the most abundant species in the Calpentyn dredging. It is larger than the ordinary run of *Cytheruræ*, has no central areola, and on the whole seems to come more appropriately under *Cythere*, though the posterior beak gives it an appearance similar to *Cytherura*. I do not now see any sufficient reason for the separation of *C. bataviana* and *C. iniqua*.

Genus Cytheridea, *Bosquet*.

Cytheridea orientalis, n. sp. (Plate XL. figs. 16–18.)

Shell, seen from the side, oblong, subovate, highest in the middle; height scarcely equal to half the length; anterior extremity rounded, posterior narrower, rounded off at the ventral angle; dorsal margin arched, sloping with a very gentle curve to the front, and much more steeply behind, ventral slightly sinuated: seen dorsally, the outline is ovate, widest in the middle, more than twice as long as broad, tapering equally to the extremities, which are pointed. Surface smooth, polished, marked with numerous circular, hair-like papillæ. Colour whitish or creamy. Length $\frac{1}{25}$ of an inch (1 millim.).

Cytheridea pusilla, n. sp. (Plate XL. figs. 13–15.)

Shell rather tumid, ovate: seen from the side, about twice as long as broad, highest in the middle; anterior extremity obliquely

rounded, posterior subtruncate; dorsal margin feebly arched, ventral almost straight: seen from above, ovate, not twice as long as broad, widest in the middle; extremities rounded, the anterior the narrower of the two. Surface of the shell smooth, marked towards the front with a few faint curved, concentric grooves, and thickly dotted with short hair-like papillæ. Length $\frac{1}{50}$ of an inch (·5 millim.)

Possibly an immature form, but not referable, I think, to any described species.

Genus Loxoconcha, *G. O. Sars.*

Loxoconcha sagittalis, n. sp. (Plate XL. figs. 19–21.)

Shell of the *male* (?), seen from the side, oblong, obliquely subquadrangular, scarcely twice as long as high, and of nearly equal height throughout; extremities equal and obliquely rounded; dorsal and ventral margins nearly parallel, dorsal slightly sinuous, ventral straight: seen from below, ovate, pointed, and tapered in front; posterior extremity wide, rounded, with a central keel; each lateral margin has just behind the middle an acute-angled alæform projection, running forwards into a sharp crest, and giving the anterior half of the shell the shape of an arrowhead. Surface of the shell irregularly rugose and bearing numerous, rather large, circular papillæ. Length $\frac{1}{42}$ of an inch (·6 millim.).

Two specimens only of this species were observed,—one an elongated angular form, which I suppose to be the male; the other shorter, broader, and more rounded in outline, probably the female.

Loxoconcha alata, *G. S. Brady*?

Loxoconcha alata, *Brady, Ann. & Mag. Nat. Hist.* ser. 4, vol. ii. (1868), p. 223, pl. xiv. figs. 8–13.

The Calpentyn specimens have a less developed lateral ala, and are more coarsely punctate, but in other respects so closely approach the types that it seems best to take them as belonging to this species. The specimens referred in the 'Challenger' Report to *L. alata* are different, and are, I think, identical with the next species.

Loxoconcha gibbera, n. sp. (Plate XL. figs. 25–27.)

Loxoconcha alata, *Brady, Report on the Ostracoda of the 'Challenger' Expedition,* p. 122, pl. xxvii. figs. 6 *a–j*.

Carapace tumid; seen from the side, obliquely quadrangular; height the same throughout and equal to about two thirds of the length; anterior extremity obliquely rounded, posterior obliquely rounded below, produced into an obtuse beak near the middle, obliquely truncate above; dorsal margin straight, with a very prominent angulated hump at the posterior extremity, ventral straight: seen from above, the outline resembles that of two triangles applied to each other by their bases—a large one in front, a smaller behind; the greatest width equal to three fourths of the length, extremities subacuminate; end-view irregular, height somewhat less than the width, broadest at the base; dorsal margin broad and irregularly arched. Surface of the shell closely set with coarse impressed punctures; hinge-tubercle glistening and prominent; a large, round, alæform process behind the middle of the valve just within the ventral margin, and a large angular prominence at the posterior end of the hinge-margin. Length $\frac{1}{55}$ of an inch (·46 millim.).

LOXOCONCHA AVELLANA, *G. S. Brady.*

Normania avellana, *Brady*, *Trans. Zool. Soc.* vol. v. (1865), p. 382, pl. lxi. figs. 15 *a–c*.

Loxoconcha avellana, *Brady*, *Report on the Ostracoda of the 'Challenger' Expedition*, p. 117, pl. xxviii. figs. 1 *a–f*.

These specimens are more tumid than the type (West Indies), but less tumid than those from Australia, figured in the 'Challenger' Report.

LOXOCONCHA PAPILLOSA, n. sp. (Plate XL. figs. 33, 34.)

Carapace seen from the side rhomboidal, height equal to more than two thirds of the length, slightly higher behind than in front; anterior extremity rounded, posterior obliquely truncated and forming a very slightly produced beak at the dorsal angle; dorsal margin very gently arched, ventral straight; all the angles except the postero-dorsal well rounded: seen from above, ovate, fully twice as long as broad, widest in the middle, extremities broadly pointed, the posterior more produced and tapered than the anterior. End-view ovate. Surface smooth and polished; ornamented with numerous closely-set raised circular papillæ. Length $\frac{1}{50}$ of an inch (·5 millim.).

LOXOCONCHA ELONGATA, n. sp. (Plate XL. figs. 31, 32.)

Carapace, seen from the side, elongated, flexuous, of equal

height throughout; height equal to half the length; extremities obliquely rounded, the anterior somewhat the narrower of the two; dorsal margin straight, almost angular behind, and gently rounded off in front, ventral also nearly straight, but upcurved behind: seen from above, ovate, twice as long as broad, with nearly equal and acuminate extremities, the anterior extremity more tapering than the posterior, widest in the middle. Surface rather coarsely sculptured with closely-set rounded fossæ. Length $\frac{1}{45}$ of an inch (·54 millim.).

Genus Xestoleberis, *G. O. Sars.*

Xestoleberis curta, *G. S. Brady.*

Cytheridea (?) curta, *Brady, Trans. Zool. Soc.* 1865, vol. v. p. 370, pl. lviii. figs. 7 *a, b.*

Xestoleberis curta, *Brady, Les Fonds de la Mer,* t. i. p. 79, pl. x. figs. 16–18; *Report on the Ostracoda of the 'Challenger' Expedition,* p. 126, pl. xxxi. figs. 6 *a–d.*

Xestoleberis intermedia, *G. S. Brady*?

Xestoleberis intermedia, *Brady, Les Fonds de la Mer,* t. i. p. 94, pl. xii. figs. 3–7; *Report on the Ostracoda of the 'Challenger' Expedition,* p. 128, pl. xxxiii. figs. 2 *a–d.*

Xestoleberis variegata, *G. S. Brady.*

Xestoleberis variegata, *Brady, Report on the Ostracoda of the 'Challenger' Expedition,* p. 129, pl. xxxi. figs. 8 *a–g.*

Xestoleberis tumefacta, *G. S. Brady.*

Xestoleberis tumefacta, *Brady, Report on the Ostracoda of the 'Challenger' Expedition,* p. 128, pl. xxxi. figs. 4 *a–d.*

Xestoleberis sulcata, n. sp. (Plate XL. figs: 28–30.)

Shell, seen from the side, oblong, subreniform, greatest height in the middle and equal to more than half the length; anterior extremity narrow, rounded, posterior broad, obliquely subtruncate; dorsal margin gently arched, highest in the middle, where it is almost angulated, ventral slightly sinuated: seen from above, ovate, not quite twice as long as broad, widest behind the middle, subacuminate in front, broadly rounded behind: end-view very broadly ovate, almost circular, dorsum pointed. Surface of the shell smooth or slightly papillose, sometimes slightly setose, marked round the margins and on the ventral surface with distinct longitudinal furrows. Length $\frac{1}{44}$ of an inch (·55 millim.).

Genus Bythocythere, *G. O. Sars.*

Bythocythere retusa, n. sp. (Plate XL. figs. 22–24.)

Shell, seen from the side, oblong, twice as long as broad, slightly higher in front than behind; anterior extremity rounded, posterior obliquely rounded off below the middle, where it forms an obtuse angle, obliquely truncated and emarginate above; dorsal margin straight, ventral gently convex: seen from below, the outline is ovate, twice as long as broad, widest in the middle; extremities strongly mucronate: end-view very irregular. The valves are slightly papillose, have a deep transverse furrow near the middle, and a sharp longitudinal crest in the middle line behind the furrow, also in the middle of each ventral margin a prominent curved ridge or ala, which ends behind in a sharp angle; anterior hinge-tubercle prominent; ventral surface flat, keeled, and longitudinally grooved. Length $\frac{1}{38}$ of an inch (·66 millim.).

Genus Paradoxostoma, *Fischer.*

Paradoxostoma cingalense, n. sp. (Plate XL. figs. 35, 36.)

Carapace compressed, oblong; seen from the side, thrice as long as broad, greatest height in the middle; anterior extremity depressed and rounded, posterior produced into a broad, obtuse beak; dorsal margin boldly arched, ventral sinuous: seen from above, oblong-ovate, quite four times as long as broad, widest in the middle and tapering evenly to the extremities, which are sharply pointed. Surface smooth, without markings. Length $\frac{1}{37}$ of an inch (·7 millim.).

DESCRIPTION OF THE PLATES.

Plate XXXVII.

Figs. 1–3. *Limnadia Hislopi*, Baird. 1. Entire animal, magnified. 2. Head and antennæ, more highly magnified. 2 *a*. Serratures of anterior part of head, still further enlarged. 3. Abdominal rami, also highly magnified.

Figs. 4 & 5. *Moina submucronata*, n. sp. 4. Animal, seen laterally, magnified. 5. Abdomen, more highly magnified.

Figs. 6–9. *Ilyocryptus Halyi*, n. sp. 6. Animal, seen laterally, magnified. 7. Portion of upper branch of posterior antenna, more highly magnified. 8. Abdomen, ditto. 9. Some of the spines of the abdomen, more highly magnified.

Figs. 10–15. *Attheyella cingalensis*, n. sp. 10. Anterior antenna of female. 11. Secondary branch of posterior antenna of same. 12. Foot of

first pair. 13. Foot of fourth pair. 14. Foot of fifth pair. 15. Posterior abdominal and caudal segments. All the figures greatly enlarged.

Figs. 16–20. *Macrothrix triserialis*, n. sp. 16. Animal seen from behind. 17. Side view of animal, both much magnified. 18. Anterior portion of head and anterior antenna, further enlarged. 19 & 20. Serratures of the ventral margins of the carapace, greatly magnified.

Figs. 21–26. *Diaptomus orientalis*, n. sp. 21. Female, seen from behind, magnified. 22. Anterior antenna of female. 23. Right anterior antenna of male. 24. Right foot of male. 25. Fifth foot of female. 26. Abdomen and caudal extremity of male. All very considerably magnified.

Plate XXXVIII.

Fig. 1. *Alona acanthocercoides*, Fischer. Animal, seen laterally, magnified.

Figs. 2–4. *Cyclops*, sp.? 2. Anterior antenna of female. 3. Fifth foot. 4. Tail with setæ. All magnified.

Figs. 5–7. *Cypris Malcolmsoni*, n. sp. 5. Postabdominal ramus. 6. Shell, from left side; 7, from above.

Figs. 8–11. *Cypris luxata*, n. sp. Shell, in different views: 8, Left side, 9, right side, 10, from above, 11, front view.

Figs. 12–14. *Cypris purpurascens*, n. sp. Shell: 12, left side, 13, from above, 14, front view.

Figs. 15–17. *Cypris Halyi*, n. sp. 15. Left side, 16, from above, 17, front view.

Figs. 18–20. *Cypris tenuicauda*, n. sp. Shell: 18, left side, 19, from above, 20, front view.

Figs. 21–23 *a*. *Cypris furfuracea*, n. sp. Shell: 21, left side, 22, from above, 23, front view. 23 *a*. A small portion of the shell-surface, much more highly magnified.

Figs. 24–27 *a*. *Chlamydotheca subglobosa*, Sowerby. Shell. 24. Right valve, seen from inside. 25. Left valve, inside view. 26. Both valves, from above. 27. Both valves, front view.

Figs. 28–30. *Cyprinotus cingalensis*, n. sp. Shell: 28, left side, 29, from above, 30, front view.

Plate XXXIX.

Figs. 1–3. *Cypridopsis globosa*, n. sp. Shell: 1, left side, 2, from above, 3, front view.

Figs. 4–6. *Pontocypris nitida*, n. sp. Shell: 4, right side, 5, from above, 6, front view.

Figs. 7–9. *Cypridopsis marmorata*. Shell: 7, left side, 8, from above, 9, front view.

Figs. 10–12. *Cypris monilifera*, n. sp. Shell: 10, right side, 11, from above, 12, front view.

Figs. 13–15. *Bairdia tenera*, n. sp. Shell: 13, left side, 14, from above, 15, front view.

Figs. 16–18. *Cythere Ruperti*, n. sp. Shell: 16, left side, 17, from above, 18, front view.

Figs. 19–22. *Cythere coralloides*, n. sp. Shell of male: 19, left side, 20, from above. Shell of female: 21, left side, 22, from above.

Figs. 23, 24. *Cythere Stimpsoni*, Brady. Shell: 23, left side, 24, from above.

Figs. 25–28. *Cythere truncatula*, n. sp. Shell of male: 25, left side, 26, from above. Shell of female: 27, left side, 28, from above.

F. Carter sc.

CEYLON ENTOMOSTRACA.

CEYLON ENTOMOSTRACA

Crowther lith. Mintern imp.

CEYLON ENTOMOSTRACA.

Mintern imp.

CEYLON ENTOMOSTRACA

Figs. 29, 30. *Cythere subcuneata*, n. sp. Shell: 29, left side, 30, from above.

Figs. 31–33. *Cythere iniqua*, Brady. Shell: 31, right side, 32, from above, 33, front view.

Figs. 34–36. *Cythere laqueata*, n. sp. Shell: 34, right side, 35, from above, 36, front view.

PLATE XL.

Figs. 1–3. *Aglaia acuminata*, n. sp. Shell: 1, right side, 2, from above, 3, front view.

Figs. 4–6. *Cythere fabacea*, n. sp. Shell: 4, left side, 5, from above, 6, front view.

Figs. 7–9. *Cythere rectangularis*, Brady. Shell: 7, left side, 8, from above, 9, front view.

Figs. 10–12. *Cythere bimamillata*, n. sp. Shell: 10, left side, 11, from above, 12, front view.

Figs. 13–15. *Cytheridea pusilla*, n. sp. Shell: 13, right side, 14, from above, 15, front view.

Figs. 16–18. *Cytheridea orientalis*, n. sp. Shell: 16, left side, 17, from above, 18, front view.

Figs. 19–21. *Loxoconcha sagittalis*, n. sp. Shell: 19, right side, 20, from below, 21, front view.

Figs. 22–24. *Bythocythere retusa*, n. sp. Shell: 22, left side, 23, from below, 24, front view.

Figs. 25–27. *Loxoconcha gibbera*, n. sp. Shell: 25, left side, 26, from above, 27, front view.

Figs. 28–30. *Xestoleberis sulcata*, n. sp. Shell: 28, left side, 29, from above, 30, front view.

Figs. 31 & 32. *Loxoconcha elongata*, n. sp. Shell: 31, right side, 32, from above.

Figs. 33 & 34. *Loxoconcha papillosa*, n. sp. Shell: 33, left side, 34, from above.

Figs. 35 & 36. *Paradoxostoma cingalense*, n. sp. Shell: 35, left side, 36, from above.

(All the figures of the Ostracoda are moderately magnified, the scale varying from about ten to forty diameters.)

On new African Genera and Species of Curculionidæ.

By FRANCIS P. PASCOE, F.L.S.

[Read 15th April, 1886.]

(PLATE XLI.)

THE localities from which the greater part of the species here described are derived are, I believe, new to scientists. They are:—Momboia*, a missionary station north of Lake Nyassa; Landana†, a new settlement on the Congo; and Mayotte, one of the Comoro Islands (off Madagascar). It may be that some of these have been already described; but entomological literature is now so extensive that it is difficult to be quite sure; particularly as so many entomologists are satisfied with giving a bare and sometimes inadequate description (*pour prendre date*, as the French say) without any reference to affinities or to diagnostic characters, often of more importance than the descriptions themselves.

I may observe that there is probably no family of insects in which greater diversity of appearance in the same genus is to be found than among the Curculionidæ. Species the most dissimilar are not to be separated by any characters which are usually deemed to be of generic importance; and in extreme cases we have to fall back on secondary characters which, after all, may be quite as natural. On the other hand, species which are very much alike in appearance are found to belong to widely different groups, while the absence in many cases of any correlation between the characters makes the classification difficult, and necessitates an undesirable but unavoidable number of genera if anything like definiteness is to be maintained.

The following is a list of the species and the subfamilies to which they belong:—

BRACHYDERINÆ.
Piazomias peregrinus.
—— macer.

Siderodactylus Oberthurii.
—— delectans.
—— puellaris.

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* I owe these species to the kindness of Mr. Simpson, of the Geographical Society.

† To M. René Oberthür, of Rennes, I am indebted for these and a number of other interesting forms obtained by his collectors in other parts of the world.

Dermatodes metallescens.
Pamphæa, n. g.
—— deficiens.
Stigmatrachelus vittatus.
—— ruptus.
—— longiceps.
—— flexuosus.
Catamonus suffusus.
Stiamus, n. g.
—— brachyurus.
Ectitheis, n. g.
—— divisus.
Platyomicus aridus.
Straticus, n. g.
—— funestus.

OTIORHYNCHINÆ.

Systates laticollis.
Dicasticus, n. g.
—— quadrinus.
—— laticollis.
—— celatus.

LEPTOPINÆ.

Ostra, n. g.
—— nodulosa.

TANYRHYNCHINÆ.

Tanyrhynchus ellipticus.

ATTELABINÆ.

Attelabus chrysideus.

BALANINÆ.

Balaninus brevirostris.
Timola, n. g.
—— suturalis.

ITHYPORINÆ*.

Desmidophorus Satanas.
—— encaustus.
Neiphagus, n. g.
—— dentatus.
—— fascicularis.

CRYPTORHYNCHINÆ.

Peristhenes, n. g.
—— adustus.

ZYGOPINÆ.

Saphicus, n. g.
—— variegatus.

CALANDRINÆ.

Stenophida, n. g.
—— linearis.

PIAZOMIAS PEREGRINUS.

P. oblongo-ovatus, niger, squamis minutis albis vestitus; prothorace nigro, ad latera linea alba munito, disco sulcis plurimis inciso. Long. 4 lin.

Hab. Delagoa Bay.

Oblong-ovate, black, clothed with very small white scales, absent, however, on the disk of the prothorax, and condensed into a conspicuous stripe on the outer margin of the elytra; head and rostrum with a longitudinal median groove, with a ridge on each side of the latter; antennæ pitchy; the second to the fourth joints of the funicle equal; prothorax subglobose, black, the disk with narrow longitudinal grooves—some confluent—and a line of white scales at the sides; elytra striate-punctate, the punctures oblong, interstices convex; body beneath at the side covered with black, the middle with white scales; legs paler, studded with white setæ.

This species resembles the Chinese *P. velatus*, but it is narrower,

* In the 'Annali del Museo Civico di Genova' (ser 2a, vol. ii. p. 248) I have ventured to raise this, one of Lacordaire's secondary groups of Cryptorhynchinæ, to the rank of a subfamily.

and the sculpture of the prothorax is very different and, so far as I know, of a kind confined to this and the following species. On the elytra of one of my specimens there are a few small black spots.

PIAZOMIAS MACER.

P. anguste-ovatus, niger, opacus, squamis concoloribus sejunctim vestitus; prothorace latitudine latiori. Long. 3 lin.

Hab. Delagoa Bay.

Narrowly ovate, opaque black, clothed with minute black non-contiguous scales; head and rostrum as in the preceding, but the second joint of the funicle longer than the succeeding ones; prothorax longer than broad, with numerous grooves; elytra more coarsely punctured and studded with white setæ; body beneath and legs pitchy brown, with numerous silvery hairs.

A slender species, with no appearance of scales except under a strong lens.

SIDERODACTYLUS OBERTHURII.

S. ellipticus, ferrugineus, griseo-squamosus; elytris leviter rotundatis, lineatim punctatis, interstitiis planis, latioribus. Long. 4 lin.

Hab. Landana.

Elliptic, ferruginous, with grey contiguous scales; rostrum shorter than the head, concave in front; antennæ pitchy, sparsely setulose; the two basal joints of the funicle equal in length; prothorax convex, longer than broad, sulcate in the middle, scales arranged in circles on slightly raised approximate granules; scutellum nearly round; elytra nearly twice as broad as the prothorax at the base, gradually rounded at the sides, punctures in narrow inconspicuous lines, the interstices broad and flat, the scales round, nearly contiguous, many brown, forming small indefinite spots; body beneath and legs scaly and setulose.

The peculiar arrangement of the scales on the prothorax at once differentiates this species, which I have dedicated to M. René Oberthür, of Rennes, to whom I am indebted for many rare species.

SIDERODACTYLUS DELECTANS.

S. oblongus, squamis læte viridulis dense tectus, setulis nigris adspersus; elytris minus convexis, seriatim punctatis, interstitiis latioribus, squamis angustis griseis uniseriatim remote obsitis. Long. 3 lin.

Hab. Old Calabar.

Oblong, densely covered with pure pale-green scales, and with

sparse black setæ; rostrum concave in front and longitudinally sulcate; eyes prominent; antennæ as in the last; prothorax rather longer than broad, the basal margin not broader than the apical, the disk with contiguous elevated scaly tubercles, each tipped with a black seta; scutellum small, narrow; elytra nearly twice as broad as the prothorax at the base, seriate-punctate interstices broad and with a single row of remote elongate greyish scales; body beneath with golden-green scales; the legs with greyish scales, all the femora with a small tooth beneath.

There are three kinds of scales on this species:—(1) the normal round scale, (2) the long narrow greyish scale like the tip of a camel's-hair brush, and (3) the seta, which is a modified scale.

Siderodactylus puellaris.

S. oblongus, squamis viridulis, postice roseo-griseis, dense tectus, setulisque nigris adspersus; elytris seriatim punctatis, interstitiis angustis parum convexis. Long. 3½ lin.

Hab. Old Calabar.

Oblong, closely covered with pale greenish, passing posteriorly into rose-grey, scales, with scattered black setæ; rostrum flat in front and longitudinally sulcate; antennæ scaly; funicle with the two basal joints equal in length; prothorax oval, the basal margin not broader than the apical, the disk with low scaly tubercles; scutellum narrowly oblong; elytra half as broad as the prothorax at the base, seriate-punctate, punctures conspicuous, interstices narrow, slightly convex; body beneath densely covered with golden-green scales; the legs with greyish, but the femora, except at the apex, with pale green scales; anterior femora with a small tooth beneath.

Perhaps a variety of the preceding, but differently coloured.

Dermatodes metallescens.

D. oblongo-ovatus, niger, squamulis viridi-metallicis undique tectus; scapo antennarum pone oculum extenso. Long. 6 lin.

Hab. Momboia.

Oblong-ovate, black, everywhere covered with pale metallic green scales; head and rostrum longitudinally sulcate; scape elongate, attaining the posterior border of the eye; prothorax rather broader than long, rounded at the sides; scutellum scutiform; elytra much broader than the prothorax at the base, the shoulders rounded, striate-punctate, the interstices slightly elevated; anterior tibiæ slightly flexuous.

I refer this species to *Dermatodes*, an Eastern genus, rather than to *Stigmatrachelus*, an African one, on account of the scaly corbels of the posterior tibiæ, the principal distinction between the two genera. The length of the scape is sometimes dependent on sex; it may be that the other sex of this species (♀?) has the shorter scape of its congeners.

Pamphæa.

Dermatode affinis. Scapus partem posteriorem oculi attingens; oculi parum prominentes. Prothorax basi rectus. Propectus brevissimum. Processus intercoxalis angustior. Abdomen segmento secundo tertio quartoque longiori; sutura prima arcuata.

In *Dermatodes*, and indeed in every large genus, these and every other character are subject to exceptions; but here, taken together, they constitute a sufficiently well-marked genus. The straight base of the prothorax and a corresponding straightness at the base of the elytra are perhaps the most prominent characters. The comparatively non-prominent eyes are accompanied by a narrower head; while in the more typical *Dermatodes* the prominence of the former is so exaggerated as, in some species, to be semi-pedunculate. The species described below is covered with approximate white hair-like scales; but with the derm showing between them, the coloration appears to be a pure pale grey.

Pamphæa deficiens.

P. anguste-ovalis, piceus, pilis albis approximatis vestitus; rostro integro, antice planato; scutello subquadrato. Long. 3½ lin.

Hab. Mayotte.

Narrowly oval, pitchy, everywhere clothed with white approximate hairs; head and rostrum not grooved, the latter flat in front; antennæ ferruginous, the two basal joints of the funicle equal, the third to the fifth gradually shorter, the last broadly triangular, club elliptic; prothorax slightly transverse; elytra broader than the prothorax at the base, the sides on the basal half nearly parallel; fore tibiæ denticulate on the inner margin.

Stigmatrachelus vittatus.

S. ovatus, niger nitidus, squamis albis vittas formantibus, in medio elytrorum fascia irregulari elevata esquamosa instructus, interstitiis nonnullis elevatis. Long. 5 lin.

Hab. Madagascar.

Ovate, black, with narrow well-defined stripes composed of

densely-set white scales; the intervals narrower, without scales, and glossy black, an irregular band (also glossy black) in the middle of the elytra; head grooved, rostrum ridged, eyes rather prominent; antennæ slender, black; the funicle with the second joint scarcely longer than the first; prothorax slightly transverse, with three elevated black stripes; elytra striate-punctate, alternate interstices narrow and glossy black, two or three near the suture elevated, the other interstices broad and flat, covered (the irregular band excepted) with white scales, forming square patches between the stripes, and coarsely punctured, the punctures in the striæ impinging on the black interstices and giving them a moniliform appearance; body beneath and legs covered with small white scales.

A remarkable species as regards colour and sculpture, but allied to *S. alternans*, which, *inter alia*, has all the interstices raised and a broad black band on the elytra followed by an equally broad white one.

Stigmatrachelus ruptus.

S. ovatus, niger nitidus, albo-squamosus; elytris fasciis irregularibus ante et pone medium macula triangulari esquamosis notatis, interstitiis postice solum sed parum elevatis. Long. 5 lin.

Hab. Madagascar.

Ovate, black, shining, closely clothed with white scales except certain parts above; eyes prominent; head grooved between the eyes; rostrum ridged in front; antennæ black; the funicle with the second joint longer than the first; prothorax with three black glossy stripes, the central broadest and longitudinally grooved; elytra seriate-punctate, punctures small, distinct, but those on the band and posterior spot large and quadrangular, interstices slightly raised posteriorly; body beneath and legs clothed, the former with white, the latter with white scales mixed with brown.

Allied to the last, but the disposition of the naked patches different, and the interstices of the elytra nearly uniform.

Stigmatrachelus longiceps.

S. oblongo-ovatus, niger, elytris squamis albidis obsitis; capite pone oculos magis elongato; rostro modice incrassato. Long. 5–6 lin.

Hab. Momboia.

Oblong-ovate, black, the disk of the elytra clothed with whitish scales; head behind the eyes elongate; rostrum rather stout, hardly longer than the head, ridged in the middle; antennæ

black, second joint of the funicle slightly longer than the first, the club elliptic; prothorax scarcely broader than long, closely punctured; scutellum small; elytra half as broad again as the prothorax, gradually narrower behind, striate-punctate, striæ linear and glossy black, the punctures oblong approximate; legs and body beneath with minute white scattered hairs.

A very distinct species, as are several others belonging to this genus; *inter alia*, it has a longer head and prothorax than any of its congeners.

STIGMATRACHELUS FLEXUOSUS.

S. ovatus, capite angustiore, oculis haud prominentibus; niger, squamis griseis fuscisque vestitus; funiculo brevi; elytris fasciis flexuosis notatis. Long. 4 lin.

Hab. Madagascar.

Ovate, black, covered with grey and brown scales, on the elytra forming irregular bands; head narrower, eyes not prominent; rostrum with a median ridge; antennæ black, all the joints of the funicle shortened, the last broadly transverse, and not very distinct from the club; prothorax broader than long, convex; elytra striate-punctate, the striæ scaled, punctures oblong, non-approximate; body beneath and legs with yellowish-grey scales and setæ.

This species departs considerably from the normal forms of the genus, but there is nothing but secondary characters to justify its separation. It has the same deep groove between the eyes as in most others of the genus.

CATAMONUS SUFFUSUS.

C. ovatus, piceus, squamis viridulis, roseo-griseisque intermixtis, dense tectus; interstitiis elytrorum squamis elongatis uni- et biseriatim obsitis. Long. 5½ lin.

Hab. Old Calabar.

Ovate, pitchy, closely covered with pale greenish and rose-grey scales; eyes not prominent; rostrum twice as long as the head, moderately stout, with a well-marked ridge in front; antennæ closely covered with grey scales and thinly setulose; second joint of the funicle longest; prothorax transverse, a large scale in each puncture, the intervals with smaller scales; scutellum subscutiform; elytra half as broad again as the prothorax at its base, finely striate-punctate, interstices raised, with one or two rows of long, narrow, greyish scales; body beneath and legs closely scaly and setulose.

In colour and sculpture very distinct from *C. melancholicus*. The intermixture of differently coloured scales—the grey predominating—makes the coloration somewhat indefinite.

STIAMUS.

Rostrum breve, capite haud abscissum; scrobes infra oculos currentes. Antennæ graciles; scapus pone oculum haud productus; funiculus tenuatus; clava distincta. Prothorax subtransversus, basi apiceque truncatus. Elytra prothorace basi paulo latiora, humeris productis. Femora incrassata, subtus dente minuto armata; tibiæ anticæ intus denticulatæ; tarsi articulo penultimo late bilobo; unguiculi basi connati. Abdomen segmentis duobus basalibus ampliatis.

This genus may be placed near *Brachyderes*, but without any salient character absolutely differentiating it from the other genera of the group to which it belongs, nearly all of which are destitute of any tangible characters; those given by Lacordaire being generally of very little more than specific value.

STIAMUS BRACHYURUS. (Plate XLI. fig. 6.)

S. obovatus, niger nitidus; elytris postice latioribus, apice singulorum producto. Long. $4\frac{1}{2}$ lin.

Hab. Mayotte.

Obovate, black, shining, with very small white setæ, and scattered minute scales; rostrum slightly concave in front; antennæ pitchy; first two joints of the funicle equal, the remainder shorter and subequal, and gradually pilose to and including the club; prothorax rounded and punctured; elytra slightly convex, gradually broader behind, then rounded to the apex, which is narrowly but shortly produced at the suture, seriate-punctate, punctures coarse and subremote, the intervals slightly corrugated; body beneath and legs with a few white setæ.

ECTITHEIS.

Caput antice rotundatum; rostrum robustum, apice utrinque elevatum; oculi rotundati, prominuli, grosse granulati. Antennæ modice elongatæ. Prothorax planatus, ad latera dilatatus, postice elevatus. Scutellum nullum. Elytra oblongo-ovata, prothorace basi latiora. Pedes mediocres, corbellis tibiarum apertis; tarsi articulo primo late triangulari; unguiculi approximati.

The flattened disk of the prothorax somewhat shortened and truncated behind, leaving an evident space above its junction with the metathorax between the disk and the elytra—is a peculiarity which at once distinguishes this genus; in some respects it

approaches *Scobius*, a heterogeneous group as it stands at present.

Ectitheis divisus. (Plate XLI. fig. 3.)

E. suboblongus, niger, vix nitidus; rostro in medio leviter, apicem versus profunde, sulcato; prothorace confertim et subtiliter punctato. Long. 5 lin.

Hab. Natal.

Suboblong; black, very slightly shining; rostrum not longer than the head, broadly and lightly sulcate at the base, deeper and narrower towards the apex; antennæ black; scape extending to the prothorax, first joint of the funicle longer than the second, the rest much shorter and conical; prothorax expanded and rounded at the sides, closely and finely punctured; elytra slightly convex, shoulders acutely produced, seriate-punctate, punctures large, approximate, interstices raised and minutely punctured; tarsi pilose.

Platyomicus aridus. (Plate XLI. fig. 5.)

P. ovatus, omnino dense fuscescenti-albido-squamosus, setulis minutis dispersus; prothorace ad latera roundato, disco trisulcato; elytris tuberculis duobus munitis. Long. 6 lin.

Hab. Momboia.

Rather broadly ovate; everywhere densely covered by brownish-white minute scales, and more or less setulose; head with a narrow impressed longitudinal line; eyes small, prominent; club of the antennæ shortly ovate, blackish; prothorax very transverse, the disk with a deep central groove and another less marked on each side; scutellum triangular; elytra broad, very convex, the shoulders angular and prominent, striate-punctate; punctures shortly linear, minute, alternate interstices elevated, behind the middle one assuming a curved form, towards the apex two small conical tubercles.

The pale colour of this species is a very marked character; like *P. echinus* and *P. cordipennis*, the prothorax is without a tubercle at the sides.

Straticus.

Caput exsertum; oculi rotundati; rostrum crassiusculum, a fronte separatum. Scrobes foveiformes. Antennæ longiusculæ, scapo prothoracem attingente, crassiusculo; funiculus linearis; clava parva, distincta. Prothorax basi truncatus. Scutellum nullum. Elytra ovata, basi prothoracis haud latiora. Pedes mediocres; femora modice incrassata, mutica; tibiæ rectæ, inermes; corbellis apertis; unguiculi basi cornuti. Abdomen segmento secundo tertio longiore.

In Lacordaire's system this genus would probably be placed with *Laparocerus*, notwithstanding its shorter and stouter antennæ, and foveiform scrobes; the former being the principal character of the "*groupe*." In facies it resembles *Calyptops granosa*, but from this genus it is at once distinguished by its connate claws.

STRATICUS FUNESTUS.

S. obscure niger; prothorace confertim granulato; elytris ovatis convexis, interstitiis granulatis. Long. 6 lin.

Hab. Momboia.

Dull black, the elytra slightly pitchy; rostrum longer than the head, tricarinate in front, the middle carina passing above the transverse groove at the base; second joint of the funicle a little longer than the first, the remainder oblong, club tomentose; prothorax moderately transverse, with numerous glossy granules; elytra ovate convex, broadly striate, the striæ closely punctate, interstices with a line of ill-defined granules; legs setulose.

SYSTATES LATICOLLIS.

S. oblongo-ovatus, niger opacus, sat sparse griseo-squamosus et setulosus; rostro acute tricarinato; scapo incrassato; prothorace transverso. Long. $3\frac{1}{2}$ lin.

Hab. Landana.

Oblong ovate; dull black, rather sparingly clothed with greyish scales and setulæ; rostrum longer than the head, with three sharply raised ridges in front; antennæ black, clothed with depressed greyish hairs; scape stout, extending to the base of the prothorax; first two joints of the funicle elongate and equal, the remainder shorter and subequal; prothorax broader than long, the apex narrower than the base, the disk with several small granules; elytra oval, striate-punctate, the punctures large, transverse, and the intervals granuliform, here and there the scales crowded and forming small grey spots; body beneath and legs with scattered scales and setulæ.

The prominent characters of this species are its stout scape extending to the base of the prothorax, the three-ridged rostrum, and the broader prothorax.

DICASTICUS.

Caput transversum; oculi rotundati prominuli; rostrum crassum a fronte abscissum; maxillæ obtectæ. Scrobes superæ, apicales, arcuatæ. Antennæ elongatæ; scapus cylindricus, crassiusculus; funiculus linearis; clava

discreta. Prothorax basi apiceque truncatus. Scutellum nullum. Elytra prothorace paulo latiora, parum convexa. Pedes mediocres; femora in media crassa; tibiæ rectæ, intus ad apicem breviter mucronatæ; tarsi articulo penultimo late bilobo; unguiculi basi connati. Abdomen segmentis duobus basalibus ampliatis.

I place this genus near the "Celeuthetides" of Lacordaire notwithstanding the connate claws, and that the "*groupe*" is almost exclusively confined to the Malaysian and Polynesian islands *.

DICASTICUS QUADRINUS. (Plate XLI. fig. 2.)

D. oblongo-ovalis, niger opacus; prothorace suboblongo; elytris in medio tuberculis quatuor (: :) rufo-nitentibus instructis. Long. 7 lin. (rostr. incl.).

Hab. Momboia.

Oblong-oval, black opaque; rostrum slightly bisulcate, narrower behind the scrobes, the latter confined to a somewhat triangular but slightly curved excavation and seen from above; antennæ black, with numerous curved setæ; scape extending to near the middle of the prothorax; first two joints of the funicle equal, the rest shorter and subequal; club elliptic; prothorax scarcely longer than broad, depressed above, with two diverging rows of nearly obsolete tubercles; elytra narrowest at the base, the humeral angles acute, the sides rounded, broadest before the middle, gradually declining behind, the apex broadly rounded; four well-marked glossy reddish tubercles on the back, and two or three nearly obsolete at the sides, the scutellar region with two oblong similar tubercles, seriate-punctate, the intervals with very minute scales.

DICASTICUS LATICOLLIS.

D. oblongo-ovatus, niger opacus; prothorace lato; elytris supra inæqualibus, basi tuberculis (circa sex) nitide-nigris instructis. Long. 6 lin.

Hab. Momboia.

Oblong-ovate, black opaque; rostrum flat anteriorly, the scrobes curved; antennæ blackish, with numerous grey setæ; first two joints of the funicle equal in length, but the basal rather thicker; prothorax much broader than long, finely punctured, the middle of the disk with a well-limited impression: elytra at the base not broader than the prothorax, the humeral angles not produced, the surface irregular and somewhat tuberculate, with small round scales and short black setæ between the punctures, close to the suture at the base about six small glossy

* Schönherr's three species of *Siteutes* are said to be from the Cape.

black granules, each elytron rounded at the apex; body beneath and legs with numerous setæ.

Readily distinguished from the last by its broad prothorax, the humeral angles not acute, and the absence of the four median tubercles.

Dicasticus celatus.

D. angustior, niger opacus; prothorace subcylindrico, supra æquali, granulis plurimis nitide nigris juxta suturam usque ad medium instructis. Long. 4 in.

Hab. Momboia.

Narrower, black opaque; rostrum with a raised median line; scrobes curved; antennæ blackish with grey setæ; first two joints of the funicle equal; prothorax rather longer than broad, the sides slightly rounded, the base and apex equal in breadth, the disk with several glossy black granules; elytra as in the two preceding, but with a regular superficies, substriate-punctate, several small granules close to the suture confined to the basal half; body beneath and legs pitchy, setulose.

The narrower form and almost cylindrical prothorax suffice to distinguish this species. In this genus and in many others the scales are easily detached, but from what remains they appear, under a strong lens, to have more or less a metallic green lustre; they are very small, but, although very close together, not contiguous.

Ostra.

Rostrum mediocre, apicem versus dilatatum, a capite separatum; scrobes apicales, superæ breves curvatæ. Antennæ graciles, scapo prothoracem attingente; funiculus linearis, articulis elongatis; clava parva, distincta. Prothorax transversus, lobis ocularibus haud prominulis. Scutellum parvum. Elytra ampliato-rotundata, prothorace basi haud latiora. Femora mutica; tibiæ haud uncinatæ; unguiculi liberi. Mesosternum breve. Abdomen segmento secundo tertio longiore.

If I am right in placing this genus near *Leptops* it will be the only African one of the "*groupe*," if we except *Gyponychus*, a doubtful member however. The ocular lobes are only moderately developed and are without vibrissæ. As in *Leptops*, the scrobes are visible from above.

Ostra nodulosa.

O. brevis, plerumque griseo-squamosa, supra tuberculato-fasciculata; rostro prothorace breviore. Long. 3 lin.

Hab. Madagascar.

Short, covered mostly with greyish scales, and fasciculated tubercles above; rostrum shorter than the prothorax, compressed above at the base, with a shallow excavation on each side between the eye and the scrobe; antennæ scaly and setulose; second joint of the funicle half as long again as the first, and equal to the three next together; prothorax short, an elongated tubercle on each side anteriorly, and many small tubercles towards the base; elytra semiglobose, each with two rows of large approximated tubercles, the spaces between with broadly impressed punctures; the base with a few glossy granules; body beneath and legs scaly and setulose.

Attelabus chrysideus.

A. silaceus, squamis piliformibus aureis sejunctim vestitus; clava antennarum articulis arcte connexis, articulo ultimo funiculi valde transverso; femoribus dente maximo instructis. Long. 2 lin.

Hab. Delagoa Bay.

Silaceous, clothed with non-approximate golden hair-like scales; head behind the eye longer than the rostrum; antennæ with the first two joints much the thickest, the last before the club very transverse; the latter stout, compact, and not distinctly separated from the funicle; prothorax bisinuate at the base, coarsely punctured, the middle with a shallow interrupted groove; scutellum indistinct but very short and very broad; elytra subquadrate, about half as long again as broad, each with four strongly marked ridges, the intervals somewhat pitted but impunctate; femora with a large triangular tooth beneath, its outer edge serrated; tibiæ sinuate at the base, the anterior denticulate; body beneath ferruginous, with a few scattered minute hairs.

Quite an isolated species so far as I know, although in some respects approaching *A. costipennis*, Fåhræus, judging from the description (Coleopt. Caffr. p. 244). It does not enter any of the sixteen sections into which the genus has been divided by M. Jekel (Insect. Saunders.).

Tanyrhynchus ellipticus. (Plate XLI. fig. 1.)

T. ellipticus, niger, elytris ferrugineis; prothorace brevi, basi semicirculari; tarsis articulo primo late cordato. Long. 4 lin.

Hab. Natal.

Elliptic; dull black, elytra ferruginous, with very small and scattered scales and setæ; rostrum slightly compressed, deeper

and curved toward the apex, and having five raised lines in front; antennæ ferruginous, scape much curved and extending to the prothorax; funicle with the six last joints equal; prothorax short, semicircular at the base, the side well rounded, the disk covered with glossy approximate granules; no scutellum; elytra oblong cordiform, moderately convex, the shoulders embracing the base of the prothorax, seriate-punctate, the interstices unequal; body beneath and legs pitchy; femora unarmed; basal joint of the tarsi broadly cordate; claws divergent.

This species is remarkable for the semicircular base of the prothorax and the corresponding sweep of the elytra; other species have the same tendency, but not to so great an extent.

BALANINUS BREVIROSTRIS.

B. fuscus, squamulis murinis sejunctim vestitus; elytris albo notatis; rostro brevi, basi incrassato; funiculo articulis tertio quartoque æqualibus. Long. 2 lin.

Hab. Landana.

Dark brown, clothed with yellowish-grey approximate scales; elytra with two or three indefinite whitish bands behind the middle; rostrum longer than the prothorax, ferruginous, thicker at the base; antennæ ferruginous; third and fourth joints of the funicle equal; prothorax rather broader than long, slightly ridged anteriorly; scutellum oblong; elytra narrowly striate-punctate, interstices broad, flat; legs ferruginous, femora acutely toothed; body beneath black, with scattered white scales.

Not unlike our *B. villosus*, which, like most others in this cosmopolitan genus, has a perfectly filiform rostrum. From the insertion of the antennæ being behind the middle of the rostrum, I believe the specimen here described to be a female; in the male the rostrum should be shorter, and the antennæ inserted in the middle. In some species the rostrum of the females is twice as long as the body.

TIMOLA.

Caput globosum; rostrum filiforme; scrobes medianæ, laterales; oculi magni, ovati. Antennæ scapo oculum attingente; funiculus elongatus; clava distincta. Prothorax transversus, basi subtruncatus. Elytra basi prothorace latiora. Pygidium breve. Pedes mediocres; femora in medio incrassata, mutica; tibiæ rectæ, inermes; tarsi æquales, articulo penultimo late bilobo, ultimo parvo; unguiculi liberi. Abdomen segmentis tribus subæqualibus, suturis rectis.

The facies of the species constituting this genus hardly suggests

a *Balaninus*, yet it does not appear to differ in any technical character. Lacordaire says of the section to which *Balaninus* belongs that, although it comprises more than thirty genera, they "present so great a variety in their organization that they represent not less than thirteen different types" (Gen. vi. p. 537).

TIMOLA SUTURALIS.

T. ovata, nigra, supra squamis oblongis silaceis lineatim ornata; rostro antennisque ferrugineis; corpore infra pedibusque sejunctim albo-squamosis. Long. $2\frac{1}{2}$ lin.

Hab. Grahamstown.

Ovate, black, with oblong silaceous scales forming well-marked lines; rostrum ferruginous, smooth, much longer than the prothorax; antennæ ferruginous; first joint of the funicle nearly as long as the two next together; club broadly oval; prothorax rugose, obsoletely punctured, a stripe on each side; scutellum triangular, covered with yellow scales; elytra slightly rounded at the sides, the suture and a stripe on the margin of the disk silaceous, striate-punctate, punctures oblong, indefinite; pygidium black; beneath and legs with white hairs and scales.

DESMIDOPHORUS SATANAS. (Plate XLI. fig. 8.)

D. suboblongo-ovatus, niger, hirsutissimus et fasciculatus; capite rude confertim punctato; rostro nitido, dimidio basali reticulato- apicali grosse sejunctim punctato; elytris fasciculis plurimis instructis. Long. 7 lin.

Hab. Madagascar.

Rather narrowly ovate comparatively; black, closely covered with long hairs, many of them fasciculate; head roughly punctured; rostrum glossy black, the basal half reticulate, the apical half with coarse punctures more apart; antennæ pitchy, smooth; funicle elongate, its second joint longest; prothorax scarcely broader than long, rounded in the middle, contracted at the base, the apex with two fascicles directed forwards; elytra at the base twice as broad as the prothorax, seriate-punctate, hairy with white hairs sparsely intermixed, the longer black hairs forming many fasciculi (about 18); legs stout, the anterior femora with a small tooth beneath; tibiæ short, thick; body beneath with few hairs.

The figure and description of Olivier's *fascicularis* (Entomol. v. p. 166, No. 83, pl. i. fig. 9), which was said to be from Cayenne, do not agree with the species known in collections as *D. penicillatus*,

Dej. Cat., and from which the above differs in its smaller size, narrow form, and sculpture of the rostrum, in which it is nearly smooth with a few small irregularly scattered punctures. The form of the scutellum is uncertain, being masked by the hairs.

Desmidophorus encaustus.

D. breviter ovatus, fuscus, pilis silaceis varius; elytris brevibus, convexis, humeris oblique truncatis, fasciculis parvulis fuscis instructis, basi maculis duabus pallidis notatis. Long. 6 lin.

Hab. Madagascar.

Shortly ovate, brown varied with silaceous hairs; rostrum black, shining, coarsely punctured; prothorax transverse, rounded at the sides, but broadest at the base, closely and deeply punctured; scutellum rounded; elytra short, convex, much broader than the prothorax at the base, shoulders obliquely truncate, striate-punctate, punctures unequal approximate; interstices raised, second, fourth, and sixth having on each three brownish fasciculi, the base with a pale oblong spot on each side the scutellum; legs with greyish hairs; femora unarmed; body beneath dark brown.

A short stout species like *D. ursus*, which is not fasciculate, has prominently angular shoulders, thick short tibiæ, and the third joint of the funicle longer than the two preceding.

Neiphagus.

Rostrum incrassatum, apice lamella triangulari elevata instructum; scrobes medianæ, obliquæ, infra oculos currentes. Oculi rotundati. Antennæ mediocres; funiculus breviusculus; clava distincta. Prothorax convexus, margine antico ad latera sinuato. Elytra convexa, postice abrupte declivia. Rima pectoralis angusta; mesosternum integrum, depressum. Abdomen segmentis tribus intermediis subæqualibus. Pedes robusti; femora antica dente parvo armata; tibiæ intus mucronatæ, posticæ corbellis cavernosis; tarsi triangulares; unguiculi basi connati.

Allied to *Desmidophorus*, but with the three intermediate segments equal or nearly equal in length, and with small connate claws.

Neiphagus dentatus. (Plate XLI. fig. 7.)

N. crassus, niger opacus, supra fere esquamosus; funiculo articulis quatuor basalibus modice elongatis et fere æqualibus; elytris haud fasciculatis. Long. 6 lin.

Hab. Momboia.

Robust, brownish black, opaque; head and rostrum closely

and coarsely punctured, each puncture enclosing a small scale; antennæ pitchy, last three joints of the funicle transverse, the four basal longer and equal; prothorax convex, narrowed anteriorly and in a slighter degree at the base, the disk with more or less confluent punctures, the middle with a longitudinal carina, the apex with two small fasciculi directed forwards; scutellum not raised; elytra twice as broad as the prothorax at the base, the shoulder conically produced, the sides gradually narrowing, but broad at the apex, coarsely seriate-punctate, the declivity with a tubercle on each side; body beneath and legs roughly scaly and setulose.

Neiphagus fascicularis.

N. crassus, fuscus, rude griseo-squamosus; funiculo antennarum articulis quatuor basalibus modice elongatis, secundo longiori; elytris fasciculis plurimis instructis. Long. 6 lin.

Hab. Momboia.

Robust, dark brown, with irregularly set grey scales; head and rostrum coarsely punctured; antennæ pitchy, the four basal joints of the funicle moderately elongate, the second longest; prothorax subtransverse, abruptly constricted anteriorly, the apex with two fasciculi, and on the convex portion behind two larger fasciculi, a well-marked median carina, and a coarse close-set punctuation on the disk, each puncture filled in with a large scale, many of them elongate and directed forwards; scutellum transverse, elevated; elytra nearly twice as broad as the prothorax at the base; the shoulder conically produced, gradually narrower to the moderately broad apex, striate-punctate, with from six to eight tuberculated fasciculi on each; legs scaly and closely setulose.

A very distinct species; the tubercles on the elytra are not all equally developed.

Peristhenes.

Rostrum mediocre; scrobes medianæ infra oculos terminatæ. Antennæ breves; funiculus leviter gradatim latior, clava continuata, hac elongata. Prothorax transversus, basi parum bisinuatus. Scutelllum elevatum. Elytra ampla, convexa. Rima pectoralis ante coxas intermedias terminata, apice cavernosa. Pedes breves; femora mutica; tibiæ intus mucronatæ; tarsi triangulares, articulo ultimo elongato; unguiculi basi connati. Abdomen segmentis duobus basalibus ampliatis.

The affinities of this genus are apparently strongest with

Ædemonus (*Erichsonii*), but the short funicle gradually passing into the club, and the connate claws are at once distinctive.

Peristhenes adustus. (Plate XLI. fig. 9.)

P. oblongus, fusco-niger opacus, prothorace elytrisque fascia postmediana, e squamulis griseis formata, obsitis. Long. 6 lin.

Hab. Momboia.

Oblong; dull brownish black, with closely set greyish scales on the prothorax and on the elytra, where they form a post-median band, broadest towards the sides; rostrum slightly curved, shorter than prothorax, and irregularly punctured; antennæ ferruginous; club nearly as long as the funicle, pubescent; prothorax small, notched at the base, a broad deep longitudinal impression at the apex, which overhangs the head; scutellum oblong oval, black; elytra much broader at the base than the prothorax and about three times as long, very convex, with large, shallow, slightly approximate punctures, the apex of each rather obliquely truncate; body beneath closely covered with rufous-grey scales; legs varied with brown scales.

Saphicus.

Antennæ funiculo 7-articulato, articulo basali elongato, secundo paullo minus elongato, cæteris gradatim brevioribus. Rima pectoralis inter coxas intermedias protensa, apice aperta. Abdcmen segmento basali ampliato, tribus intermediis brevissimis. Pygidium obtectum. Femora compressa, breviter dentata, postica elongata. Corpus crassum.

The character of the pectoral canal extending beyond the intermediate coxæ clearly differentiates this genus from *Psalistus*, Gerst., in which it does not pass beyond the anterior coxæ. *Sphadasmus*, with which it agrees in facies, has no pectoral canal.

Saphicus variegatus. (Plate XLI. fig. 4.)

S. brevis, niger, pilis niveis interrupte maculatim vestitus; antennis piceis; rostro modice elongato, medio basali carinato; prothorace transverso, in medio alte elevato et acute carinato, basi fortiter bisinuato; scutello oblongo; elytris brevissimis, in medio valde gibbosis, apice singulorum rotundato; tibiæ compressæ; tarsis posticis articulo basali elongato. Long. 4 lin.

Hab. Madagascar.

STENOPHIDA.

Opisthene affinis, sed articulo penultimo tarsorum integro, versus apicem excavato, ultimo elongato, in excavatione postice inserto; unguiculis liberis; pygidio deflecto, apice rotundato.

Oxyopisthen, Thoms., was intended to supersede Schönherr's *Megaproctus*, the name being preoccupied; but Lacordaire, considering the African species generically distinct from the Indian, adopted the name in his great work (Gen. des Coléopt. viii. 282), with characters confining it to the former. In *Oxyopisthen* the large penultimate joint has a short cleft for the insertion of the claw-joint; the claws short and united; and the pygidium subhorizontal and pointed at the apex. The species here described has the narrow contour of a *Periphemus*.

STENOPHIDA LINEARIS.

S. elongata, parallela, picea; elytris lineatim striato-punctatis; interstitiis latis planatis, uniseriatim punctatis. Long. 3 lin.

Hab. Momboia.

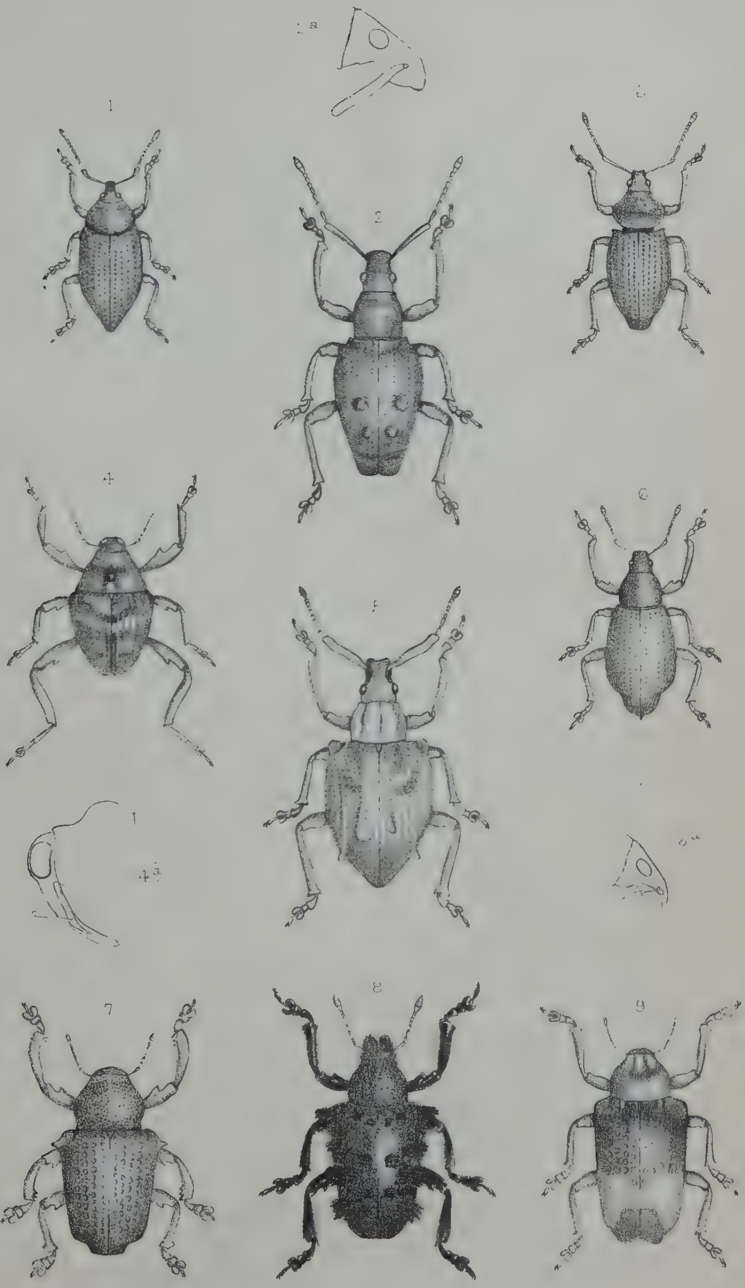
Narrowly elongate, parallel at the sides, pitchy; head between the eyes with a shallow depression; rostrum slightly curved and closely punctured; first joint of the funicle rather larger than the second, the club not broadly triangular; prothorax nearly as long as the elytra, finely and closely punctured; scutellum elongate; elytra narrowly striate-punctate, punctures inconspicuous, interstices broad and flat, each with a row of close-set round punctures; pygidium punctured at the base, beyond studded with white scales; body beneath finely punctured; tibiæ sulcated, strongly mucronate.

DESCRIPTION OF PLATE XLI.

Fig. 1. *Tanyrhynchus ellipticus.*
2. *Dicasticus quadrinus.*
2*a*. Ditto, side view of head.
3. *Ectitheis divisus.*
4. *Saphicus variegatus.*
4*a*. Ditto, a partial side view in outline.

Fig. 5. *Platyomicus aridus.*
6. *Stiamus brachyurus.*
6*a*. Ditto, side view of head.
7. *Neiphagus dentatus.*
8. *Desmidophorus Satanas.*
9. *Peristhenes adustus.*

All the figures are greatly enlarged from nature; figs. 7 and 9 are relatively much too broad.



M. H. Fisher lith.

NEW AFRICAN CURCULIONIDÆ

Mintern imp.

Physiological Selection; an Additional Suggestion on the Origin of Species.

By GEORGE J. ROMANES, M.A., LL.D., F.R.S., F.L.S.

[Read 6th May, 1886.]

INTRODUCTION.

THERE can be no one to whom I yield in my veneration for the late Mr. Darwin, or in my appreciation of his work. But for this very reason I feel that in now venturing to adopt in some measure an attitude of criticism towards that work, a few words are needed to show that I have not done so hastily, or without due premeditation.

It is now fifteen years since I became a close student of Darwinism, and during the greater part of that time I have had the privilege of discussing the whole philosophy of Evolution with Mr. Darwin himself. In the result I have found it impossible to entertain a doubt, either upon Evolution as a fact, or upon Natural Selection as a method. But during all these years it has seemed to me that there are certain weak points in the otherwise unassailable defences with which Mr. Darwin has fortified his citadel, or in the evidences with which he has surrounded his theory of natural selection. And the more I have thought upon these points, the greater has seemed the difficulty which they present; until at last I became satisfied that some cause, or causes, must have been at work in the production of species other than that of natural selection, and yet of an equally general kind.

While drifting into this position of scepticism with regard to natural selection as in itself a full explanation of the origin of species, it was to me a satisfaction to find that other evolutionists, including Mr. Darwin himself, were travelling the same way. And since Mr. Darwin's death the tide of opinion continues to flow in this direction; so that at the present time it would be impossible to find any working naturalist who supposes that survival of the fittest is competent to explain all the phenomena of species-formation; while on the side of general reasoning we need not go further than the current issue of the 'Nineteenth Century' to meet with a systematic statement of this view by the highest living authority upon the philosophy of evolution. There-

fore, in now adopting an attitude of criticism towards certain portions of Mr. Darwin's work, I cannot feel that I am turning traitor to the cause of Darwinism. On the contrary, I hope thus to remove certain difficulties in the way of Darwinian teaching; and I well know that Mr. Darwin himself would have been the first to welcome my attempt at suggesting another factor in the formation of species, which, although quite independent of natural selection, is in no way opposed to natural selection, and may therefore be regarded as a factor supplementary to natural selection.

Difficulties against Natural Selection as a Theory of the Origin of Species.

The cardinal difficulties in the way of natural selection, considered as a theory of the origin of species, are three in number:—

1st. The difference between natural species and domesticated varieties in respect of fertility.

Mr. Darwin himself allows that this difference cannot be explained by natural selection; and indeed proves very clearly, as well as very candidly, that it must be due to causes hitherto undetected. As we shall presently find, he treats this difficulty at greater length and with more elaboration than any other; but, as we shall also find, entirely fails to overcome it. Now, seeing of how much importance to any theory on the origin of species is the great and general fact of sterility between species, I need not wait to show how heavily we must here discount the theory of natural selection, considered as a theory to explain the transmutation of species.

2nd. Another fact of almost equal generality is that the features, even other than sterility *inter se*, which serve to distinguish allied species, are frequently, if not usually, of a kind with which natural selection can have had nothing whatever to do; for distinctions of specific value frequently have reference to structures which are without any utilitarian significance. It is not until we advance to the more important distinctions between genera, families, and orders that we begin to find, on any large or general scale, unmistakeable evidence of utilitarian meaning.

This difficulty, as I have MS evidence to show, was first perceived by Mr. Darwin himself; it was afterwards presented in a formidable shape by the German palæontologist Bronn, and subsequently by Broca, Nägeli, and sundry lesser writers as regards

both plants and animals. To all these criticisms Darwin replies in the last editions of his works*, with what degree of success I will presently consider.

3rd. The third and last difficulty which I have to mention consists in the swamping influence upon an incipient variety of free intercrossing. This difficulty was first prominently announced in an anonymous essay by the late Professor Fleeming Jenkin of Edinburgh, published in the 'North British Review' for 1867 †. If to this difficulty we add the consideration adduced

* See 'Origin of Species,' ed. 6, pp. 156–157 and 169–176. 'Variation' &c. ii. pp. 211–219. And as to Instincts, 'Mental Evolution in Animals,' pp. 378–379.

† This article is in all respects a highly remarkable one, and, for the space it covers, presents more searching and effective criticism of Mr. Darwin's theory than any other essay with which I am acquainted. With regard to this particular difficulty from the swamping effects of intercrossing, the criticism is especially cogent, and, so far as I know, is the only criticism of importance which Mr. Darwin has not expressly answered. Without reproducing all the numerical calculations wherewith the author sustains this criticism, it will here be enough to quote one of his illustrations:—

"Suppose a white man to have been wrecked on an island inhabited by negroes, and to have established himself in friendly relations with a powerful tribe whose customs he has learnt. Suppose him to possess the physical strength, energy, and ability of a dominant white race, and let the food and climate of the island suit his constitution; grant him every advantage which we can conceive a white to possess over the native; concede that in the struggle for existence his chance of a long life will be much superior to that of the native chiefs. Yet from all these admissions there does not follow the conclusion that after a limited or unlimited number of generations the inhabitants of the island will be white. Our shipwrecked hero would probably become king; he would kill a great many blacks in the struggle for existence; he would have a great many wives and children, while many of his subjects would live and die as bachelors; an insurance company would accept his life at perhaps one tenth of the premium which they would exact from the most favoured of the negroes. Our white's qualities would certainly tend very much to preserve him to a good old age; and yet he would not suffice in any number of generations to turn his subjects' descendants white. It may be said that the white colour is not the cause of the superiority. True; but it may be used simply to bring before the senses the way in which qualities belonging to one individual in a large number must be gradually obliterated. In the first generation there will be some dozens of intelligent young mulattoes, much superior in average intelligence to the negroes. We might expect the throne for some generations to be occupied by a more or less yellow king; but can any one believe that the whole island will gradually acquire a white or even a yellow population, or that the islanders would acquire the energy, courage, ingenuity, patience, self-control, endurance, in virtue of which qualities our hero killed so many of their

by this author, and afterwards in a more elaborate form by Professor Mivart, as to the improbability of a variation being from the first of sufficient utility to come under the influence of natural selection, I feel it impossible to doubt that a most formidable opposition is presented. For even if, for the sake of argument, we waive Professor Mivart's objection as to the probable inutility of many incipient variations which afterwards, or in a higher degree of perfection, begin to become useful, even if we waive this objection and assume that all useful variations are useful from the first moment of variation, still we have to meet the difficulty from the swamping effects of free intercrossing on the incipient variation, however useful.

Here then we have three great obstructions in the road of natural selection, considered as an explanation of the origin of species. For the sake of brevity I will hereafter allude to these difficulties as those relating to sterility, to inutility, and to intercrossing. Let us now consider how these difficulties have been dealt with in the later editions of Mr. Darwin's works.

Sterility between Species.

Founding his argument for natural selection upon the basis furnished by the known effects of artificial selection, Mr. Darwin had to meet the question why it is that the supposed products of the former differ from the known products of the latter in being so much more sterile *inter se*; or, in other words, why it is that natural species differ so conspicuously from artificial varieties in respect of mutual fertility. In order to meet this question, Mr. Darwin adduced a variety of considerations, each of which he substantiated by so large an accumulation of facts, that, as I have already observed, his discussion of the question as a whole is one of the most laboured portions of all his laborious work. From which we may perceive how fully Mr. Darwin recognized the formidable nature of this difficulty. I will now summarize the considerations whereby he sought to overcome it. And this I can do most briefly by arranging them in an order of my own.

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ancestors, and begot so many children; those qualities, in fact, which the struggle for existence would select, if it could select anything?

"Here is a case in which a variety was introduced with far greater advantages than any sport ever heard of, advantages tending to its preservation, and yet powerless to perpetuate the new variety."

In the first place, differences of type in nature are by naturalists classified as differences of species, principally because they are found to be mutually sterile. Thus it is but circular reasoning to argue that all natural species are shown by nature herself to differ from artificial varieties in presenting this peculiarity of mutual sterility; for it is mainly in virtue of presenting this peculiarity that they have been classified as species. The real question, therefore, that stands to be considered is simply this: Why should the modifications of organic types supposed to have been produced by natural selection have so frequently and generally led to mutual sterility, when even greater modifications of such types known to have been produced by artificial selection continue to be mutually fertile?

In the next place, the distinction in question is not absolute. On the one hand, some few domesticated varieties, when crossed with one another, exhibit a more or less marked degree of sterility; and, on the other hand, a large number of wild species, when crossed with one another, exhibit fertility, and this in all degrees. So that the distinction between natural species and artificial varieties in respect of fertility is, as a matter of fact, not absolute, but breaks down in both its parts.

Nevertheless, although this distinction is not absolute, it is undoubtedly, and as a general rule, valid. That is to say, it is unusual or exceptional to find complete fertility between natural species, and it is still more so to find even partial sterility between artificial varieties. Therefore, notwithstanding his success in showing that there is no absolute distinction between species and varieties in this respect, Mr. Darwin plainly peceived that there still remained a relative distinction of a most general and important kind. In order to mitigate the severity of this distinction, he furnished elaborate proof of the following facts.

1st. That with natural species the cause of sterility lies exclusively in differences of the sexual system.

2nd. That the conditions of life which occur under domestication tend to enhance fertility, and this to such an extent as to render the domesticated descendants of mutually sterile species mutually fertile, as in the case of our domesticated dogs.

Now, these two facts undoubtedly help to explain why the great changes of organic types produced by artificial selection have not resulted in superinducing mutual sterility; but they do not appear to throw any light at all on the question, why it is

that smaller changes of organic type, when produced by natural selection and now known as species, should so generally be attended with this result? Or, as Mr. Darwin himself expresses it, "the real difficulty in our present subject is not, as it appears to me, why domestic varieties have not become mutually infertile when crossed, but why this has so generally occurred with natural varieties, as soon as they have been permanently modified in a sufficient degree to take rank as species."

Here, then, we have the core of the problem; and it is just here that Mr. Darwin's explanations fail. For he candidly says, "We are far from precisely knowing the cause;" and the only suggestion he adduces to account for the fact is, that varieties occurring under nature "will have been exposed during long periods of time to more uniform conditions than have domesticated varieties; and this may well make a wide difference in the result." I need scarcely wait to show the feebleness of this suggestion. When we remember the incalculable number of animal and vegetable species, living and extinct, we immediately feel the necessity for some much more general explanation of their existence than is furnished by supposing that their mutual sterility, which constitutes their most general or constant distinction, was in every case due to some incidental effect produced on the generative system by uniform conditions of life. To say nothing of the antecedent improbability, that in all these millions and millions of cases the reproductive system should happen to have been affected in this peculiar way by the merely negative condition of uniformity, there is, as it seems to me, the overwhelming consideration that, at the time when a variety is first forming, this condition of prolonged exposure to uniform conditions of life must necessarily be absent as regards that variety; yet this is just the time when we must suppose that the infertility with its parent form arose. For, if not, the incipient variety would at once have been re-absorbed into the parent form by intercrossing, as we shall see more fully under the next head of this criticism.

In view of these considerations I conclude, that while Mr. Darwin has given the best of reasons to show why domesticated varieties have so rarely become sterile *inter se*, he has entirely failed to suggest any reason why this should so generally have been the case with natural species.

Swamping Effects of Intercrossing.

On this subject Mr. Darwin writes, "Most animals and plants keep to their proper homes, and do not needlessly wander about; we see this with migratory birds, which almost always return to the same spot. Consequently, each newly-formed variety would generally be at first local, as seems to be the common rule with varieties in a state of nature; so that similarly modified individuals would soon exist in a small body together, and would often breed together. If the new variety were successful in its battle for life, it would slowly spread from a central district, competing with and conquering the unchanged individuals on the margin of an ever-increasing circle."*

Now, to my mind, these considerations do not dispose of the difficulty in question. In the first place, a very large assumption is made when the newly-formed variety is spoken of as represented by "similarly modified individuals"—the assumption, namely, that the same variation occurs simultaneously in a number of individuals inhabiting the same area. Of course, if this assumption were granted, there would be an end of the present difficulty; for if a sufficient number of individuals were thus simultaneously and similarly modified, there need be no longer any danger of the variety becoming swamped by intercrossing. But the force of the difficulty consists in the very fact of this assumption being required to meet it. The theory of natural selection, as such, furnishes no warrant for supposing that the same beneficial variety should arise in a number of individuals simultaneously. On the contrary, the theory of natural selection trusts to the chapter of accidents in the matter of variation; and in this chapter we read of no reasons why the same beneficial variation should arise simultaneously in a sufficient number of individual cases to prevent its being swamped by intercrossing with the parent form. Or, to state the case in other words, in whatever measure the assumption in question is resorted to, in that measure is the theory of natural selection confessed inadequate to furnish an explanation of the origin of species. And to this must be added the important consideration already adduced, namely, that a very large proportion, if not the majority, of features which serve to distinguish species from species are features presenting no utilitarian significance; and

* 'Origin of Species,' ed. 6, pp. 72–3 *et seq.*

therefore that, even if they were each conceded to have arisen in a number of individuals simultaneously, they would not have benefited those individuals in their struggle for existence with the parent form. Hence their re-absorption by intercrossing would not be hindered by natural selection, which is the agency here invoked by Mr. Darwin to account for their continuance. This consideration, however, introduces us to the third and last of the difficulties with which the theory of natural selection is beset.

Inutility of Specific Characters.

The only answer which Mr. Darwin makes to this difficulty is, that structures and instincts which appear to us useless may nevertheless be useful. But this seems to me a wholly inadequate answer. Although in many cases it may be true, as indeed it is shown to be by a number of selected illustrations furnished by Mr. Darwin, still it is impossible to believe that it is always, or even generally so. In other words, it is impossible to believe that in all, or even in most, cases where minute specific differences of structure or of instinct are to all appearance useless, they are nevertheless useful. Observe, the case would be different if the great majority of specific distinctions, like the great majority of larger distinctions, were of obvious utilitarian significance. In this case we might reasonably set down the exceptions as proof of the rule, or hold that they appear to be exceptions only on account of our ignorance. But it is certainly too large a demand upon our faith in natural selection to appeal to the argument from ignorance, when the facts require that this appeal should be made over so very large a number of instances. We might, for example, most reasonably conclude that the callosities on the hind legs of horses, or the instinct of covering their excrement shown by certain roaming Carnivora, are of some such hidden use to the animals as to have preserved them in their struggle for existence. I say, we might reasonably conclude this, provided that such instances were exceptional. But seeing that so enormous a number of specific peculiarities are in the same predicament, it surely becomes the reverse of reasonable so to pin our faith to natural selection as to conclude that all these peculiarities must be useful, whether or not we can perceive their utility. For by doing this we are but reasoning in a circle. The only evidence we have of natural selection is furnished by the observed utility

of innumerable structures and instincts which for the most part are of generic, family, or higher order of taxonomic value. Therefore, unless we reason in a circle, it is not competent to argue that the apparently useless structures and instincts of specific value are due to some kind of utility which we are unable to perceive. But I need not argue this point, because in the later editions of his works Mr. Darwin freely acknowledges that a large proportion of specific distinctions must be conceded to be useless to the species presenting them; and, therefore, that they resemble the great and general distinction of mutual sterility in not admitting of any explanation by the theory of natural selection.

Natural Selection not a Theory of the Origin of Species.

In view of the foregoing considerations it appears to me obvious that the theory of natural selection has been misnamed; it is not, strictly speaking, a theory of the origin of *species*: it is a theory of the origin—or rather of the cumulative development—of *adaptations*, whether these be morphological, physiological, or psychological, and whether they occur in species only, or likewise in genera, families, orders, and classes. These two things are very far from being the same; for, on the one hand, in an enormously preponderating number of instances, adaptive structures are common to numerous species; while, on the other hand, the features which serve to distinguish species from species are, as we have just seen, by no means invariably—or even generally—of any adaptive character. Of course, if this were not so, or if species always and only differed from one another in respect of features presenting some utility, then any theory of the origin of such adaptive features would also become a theory of the origin of the species which present them. As the case actually stands, however, not only are specific distinctions very often of no utilitarian meaning; but, as already pointed out, the most constant of all such distinctions is that of sterility, and this the theory of natural selection is confessedly unable to explain.

For these reasons I think there can be no doubt that the theory of natural selection ought to be recognized as exclusively a theory of the evolution of adaptive modifications; not therefore or necessarily a theory of the evolution of different species. And, if once this important distinction is clearly perceived, the

theory in question is released from all the difficulties which we have been considering. For these difficulties have beset the theory only because it has been made to pose as a theory of the origin of species; whereas, in point of fact, it is nothing of the kind. In so far as natural selection has had anything to do with the genesis of species, its operation has been, so to speak, incidental; it has only helped in the work of originating species in so far as some among the adaptive variations which it has preserved happen to have constituted differences of only specific value. But there is an innumerable multitude of other such differences with which natural selection can have had nothing to do—particularly the most general of all such differences, or that of mutual sterility—while, on the other hand, by far the larger number of adaptations which it has preserved are now the common property of numberless species. Let it, therefore, be clearly understood that it is the office of natural selection to evolve adaptations—not therefore or necessarily to evolve species. Let it also be clearly understood that in thus seeking to place the theory of natural selection on its true logical footing, I am in no wise detracting from the importance of that theory. On the contrary, I am but seeking to release it from the difficulties with which it has been hitherto illegitimately surrounded*.

Again, it is comparatively seldom that we encounter any difficulty in perceiving the utilitarian significance of generic and family distinctions, while we still more rarely encounter any such difficulty in the case of ordinal and class distinctions. Why, then, should we so often encounter this difficulty in the

* It will be at once apparent how this release is effected. For, if it be clearly recognized that natural selection has to do with the evolution of species only in so far as specific distinctions happen to be of utilitarian character, all objections to the theory raised from its inability to explain the whole origin of species (or the general fact of sterility between allied species, and the frequently non-utilitarian character of specific distinctions) become irrelevant; whatever its professions may have been, in point of fact the theory has nothing to do with explaining any of these things, and, therefore, ought never to have been held responsible for their explanation. Again, as regards the difficulty from the overwhelming effects of intercrossing, this really concerns the theory of natural selection only in the case of varieties; not in that of species, genera, families, &c. Yet the work of natural selection in maintaining and perfecting adaptive structures in these higher taxonomic divisions is probably of quite as much importance as its work in seizing upon the earliest beneficial variations, although this fact has been lost sight of in the eagerness of naturalists to constitute the theory an explanation of the origin of species.

case of specific distinctions? Surely because some cause other than natural selection must have been at work in the differentiation of species, which has operated in a lesser degree in the differentiation of genera, and probably not at all in the differentiation of families, orders, and classes. Such a cause it is the object of the present paper to suggest; and if in the foregoing preamble it appears somewhat presumptuous to have insinuated that Mr. Darwin's great work on the 'Origin of Species' has been misnamed, I will conclude the preamble with a quotation from that work itself, which appears at once to justify the insinuation, and to concede all that I require.

"Thus, as I am inclined to believe, morphological differences, which we consider as important, such as the arrangement of the leaves, the division of the flower or of the ovarium, the position of the ovules, &c., first appeared in many cases as fluctuating variations, which sooner or later became constant through the nature of the organism and of the surrounding conditions, as well as through the intercrossing of distinct individuals; but not through natural selection; for as these morphological characters do not affect the welfare of the species, any slight variations in them could not have been governed or accumulated through this latter agency. It is a strange result which we thus arrive at, namely that characters of slight vital importance to the species are the most important to the systematist"*.

* 'Origin of Species,' ed. 6, p. 176. See also p. 365 *et seq.* The argument is that the guiding principle of classification being a hitherto unconscious tracing of the lines of genetic descent, and heredity not being more concerned with preserving useful variations than indifferent ancestral peculiarities, the latter are now of more use than the former to systematists, seeing that they have been allowed to persist without undergoing adaptive modification at the hands of natural selection. I have no doubt that this argument is sound; but the "strange result" to which it leads implies that natural selection has throughout been the cause of the origin of adaptations; not therefore necessarily, or even generally, of the origin of species. But let me not be misunderstood. In saying that the theory of natural selection is not, properly speaking, a theory of the origin of species, I do not mean to say that the theory has no part at all in explaining such origin. Any such statement would be in the last degree absurd. What I mean to say is that the theory is one which explains the origin or the conservation of adaptations, whether structural or instinctive, and whether these occur in species, genera, families, orders, or classes. In so far, therefore, as useful structures are likewise species-distinguishing structures, so far is the theory of their origin also a theory of the origin of the species which present them. But useful structures and species-distinguishing struc-

Evolution of Species by Independent Variation.

Enough has now been said to justify the view that there must be some cause or causes, other than natural selection, operating in the evolution of species. And this is no more than Mr. Darwin himself has expressly and repeatedly stated to have been his own view of the matter; nor am I aware that any of his followers have thought otherwise. Hitherto the only additional causes of any importance that have been assigned are use and disuse, sexual selection, correlated variability, and yet another principle which I believe to have been of much more importance than any of these—not even excepting the first, where the origin of species only is concerned. Yet it has attracted so little attention as scarcely ever to be noticed by writers on Evolution, and never even to have received a name. For the sake of convenience, therefore, I will call this principle the Prevention of Intercrossing with Parent Forms, or the Evolution of Species by Independent Variation.

First, let us consider how enormous must be the number of variations presented by every generation of every species. According to the Darwinian theory, it is only those variations which happen to have been useful that have been preserved; yet, even as thus limited, the principle of variability is held to have been sufficient to furnish material out of which to construct the whole adaptive morphology of nature. How immense, therefore, must be the number of unuseful variations. These are probably many hundred of times more numerous than the useful variations, although they are all, as it were, stillborn, or allowed to die out immediately by intercrossing. Hence, as a matter of fact, we find that no one individual "is like another all in all;" which is another way of saying that a specific type may be regarded as

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tures are very far from being convertible terms. On the one hand, as we have seen, many useful structures are shared by many species in common; and, on the other hand, many species-distinguishing structures are not useful. Therefore I say that the theory which explains the origin of useful structures is not, strictly speaking, a theory of the origin of species; it only explains the origin of species in cases where it happens that one species differs from another in respect of features all of which present utilitarian significance. And this, as even Mr. Darwin himself allows, is very far from being universally, or even usually, the case.

the average mean of all individual variations, any considerable departure from this average being, however, checked by intercrossing.

But now, should intercrossing by any means be prevented, there is no reason why unuseful variations should not be perpetuated by heredity quite as well as useful ones when under the nursing influence of natural selection—as, indeed, we see to be the case in our domesticated productions. Consequently, if from any cause a section of a species is prevented from intercrossing with the rest of its species, we might expect that new varieties—for the most part of a trivial and unuseful kind—should arise within that section, and that in time these varieties should pass into new species. And this is just what we do find. Oceanic islands, for example, are well known to be extraordinarily rich in peculiar species; and this can best be explained by considering that a complete separation of the fauna and flora on such an area permits them to develop independent histories of their own, without interference by intercrossing with their originally parent forms. We see the same principle exemplified by the influence of geographical barriers of any kind, and also by the consequences of migration. For when a species begins to disperse in different directions from its original home, those members of it which constitute the vanguard of each advancing army are much more likely to perpetuate any individual variations that may arise among them, than are the members which still occupy the original home. Not only is the population much less dense on the outskirts of the area occupied by the advance guard; but beyond these outskirts there lies a wholly unoccupied territory upon which the new variety may gain a footing during the progress of its further migration. Thus, instead of being met on all sides by the swamping effects of intercrossing with its parent form, the new variety is now free to perpetuate itself with comparatively little risk of any such immediate extinction. And the result is that wherever we meet with a chain of nearly allied specific forms so distributed as to be suggestive of migration with continuous modification, the points of specific difference are trivial or non-utilitarian in character. Clearly this general fact is in itself enough to prove that, given an absence of overwhelming intercrossing, independent variability may be trusted to evolve new species. The evidence which I have collected, and

am collecting, of this general fact must be left to constitute the subject of a future publication*.

Physiological Selection, or Segregation of the Fit.

Were it not for the very general occurrence of some degree of sterility between allied species, and were it not also for the fact that closely allied species are not always, or even generally, separated from one another by geographical barriers †, one might reasonably be disposed to attribute all cases of species-formation by independent variability to the prevention of intercrossing by geographical barriers, and by migration. But it is evident that these two facts can no more be explained by the influence of geographical barriers, or by migration, than they can be by the influence of natural selection. It is therefore the object of the present paper to suggest an additional factor in the formation of specific types by independent variability, and one which appears to me fully competent to explain both the general facts just mentioned.

Of all parts of those variable beings which we call organisms, the most variable is the reproductive system. It is needless for me to remind any reader of Mr. Darwin's works what a mass of evidence he has accumulated, showing the extreme sensitiveness of the reproductive system to small changes in the conditions of life.

The consequent variations may occur either in the direction of increased fertility, as with our domesticated varieties, or in that of sterility in all degrees, as with wild species when confined. So extreme is the sensitiveness of the reproductive system in these respects—or, in other words, so liable is this system to vary—

* So far as I am aware, the first writer who insisted on the great importance of the prevention of intercrossing in the evolution of species, both by isolation and migration, was Moritz Wagner. Since then Wallace, Weismann, and others, as also Darwin himself, have in lesser degrees recognized this factor. The most recent contribution to the subject is by a Fellow of this Society, Mr. Charles Dixon, whose work on 'Evolution without Natural Selection' presents a large and admirable body of facts, showing the important part which the prevention of intercrossing has played in the evolution of species among Birds. But I cannot find that any previous writer has alluded to the principle which it is the object of the present paper to enunciate, and which is explained in the succeeding paragraphs.

† As Mr. Wallace observes, allied species usually occupy contiguous areas, which more often than not are likewise continuous.

that in many cases, even when tamed in their own countries, allowed freedom, fed on their natural food, and so forth, animals become absolutely sterile. Moreover, so delicately is the reproductive system balanced in respect of variability, that sometimes it will change in the direction of sterility and sometimes in the opposite direction of increased fertility, under a change of conditions the same in kind, but different in degree. Lastly, in numberless individual cases variability occurs in either of these two opposite directions without any assignable reason at all, or, in Mr. Darwin's language, spontaneously. So that, on the whole, we must accept it as a fact that the reproductive system, both in plants and animals, is preeminently liable to vary, and this both in the direction of sterility and in that of increased fertility. Indeed, Mr. Darwin goes so far as to say: "It would appear that any change in the habits of life, whatever these habits may be, if great enough, tends to affect, in an inexplicable manner, the powers of reproduction." And he adds this important qualification: "The result depends more on the constitution of the species than on the nature of the change; for certain whole groups are affected more than others; but exceptions always occur, for some species in the most fertile groups refuse to breed, and some in the most sterile groups breed freely."

Now, having regard to all these delicate, complex, and for the most part hidden conditions which determine this double kind of variation within the limits of the reproductive system, there can be no difficulty in granting that variations in the direction of greater or less sterility must frequently occur in wild species. Probably, indeed, if we had any means of observing this point, we should find that there is no one variation more common; but of course, whenever it arises, whether as a result of changed conditions of life, or, as we say, spontaneously, it immediately becomes extinguished, seeing that the individuals which it affects are less able, if able at all, to propagate the variation; or, if the variation should extend to all the individuals of a species under a change of environment, that the species would become extinct.

Let these three points, then, be clearly kept in mind: 1st, that when a section of any species is cut off by geographical barriers, or by migration, from intercrossing with its parent form, it tends to run into new varieties, and so eventually to develop new

species; 2nd, that the number of un-useful variations taking place in all species is incalculable; and 3rd, that the reproductive system is so especially variable, both intrinsically and in response to changed conditions of life, that increase of sterility must often arise as a variation under nature.

I have now fully, if not tediously, prepared the way for explaining the suggestion which I have to make. From what has been said it may be concluded that all the multitude of individual variations perpetually occurring in every species become reabsorbed in the specific type by intercrossing, unless the variations happen to be either useful, to take place in isolation, or by way of what Mr. Spencer calls "direct equilibration," such as use, disuse, and so forth. It has also been shown that any variations in the reproductive system which take place in the direction of increased sterility must likewise tend to become extinguished. But now it must be added that there is one such variation in the reproductive system to which this remark does not apply. For if the variation be such that the reproductive system, while showing some degree of sterility with the parent form, continues to be fertile within the limits of the varietal form, in this case the variation would neither be swamped by intercrossing, nor would it die out on account of sterility. On the contrary, the variation would be perpetuated with more certainty than could a variation of any other kind. For, in virtue of increased sterility with the parent form, the variation would not be exposed to extinction by intercrossing; while, in virtue of continued fertility within the varietal form, the variation would perpetuate itself by heredity, just as in the case of variations generally when not re-absorbed by intercrossing. To make my meaning perfectly clear I will use an illustration.

Suppose the variation in the reproductive system is such that the season of flowering or of pairing becomes either advanced or retarded. Whether this variation be, as we say, spontaneous, or due to any change of food, habitat, climate, etc., does not signify. The only point we need here attend to is that some individuals, living on the same geographical area as the rest of their species, have varied in their reproductive systems, so that they can only propagate with each other. They are thus perfectly fertile *inter se*, while absolutely sterile with all the other members of their species. This particular variation being communicated by inheritance to their progeny, there would soon arise on the same area,

or, if we like, on closely contiguous areas, two varieties of the same species, each perfectly fertile within its own limits, while absolutely sterile with one another. That is to say, there has arisen between these two varieties a barrier to intercrossing which is quite as effectual as a thousand miles of ocean; the only difference is that the barrier, instead of being geographical, is physiological.

Now, from this illustration I hope it will be obvious that wherever any variation in the highly variable reproductive system occurs, tending to sterility with the parent form while not impairing fertility with the varietal form—no matter whether this is due, as here supposed, to a slight change in the season of reproductive activity, or to any other cause—there the physiological barrier in question must interpose, with the result of dividing the species into two parts. And it will be further evident that when such a division is effected, the same conditions are furnished to the origination of new species as are furnished to any part of a species when separated from the rest by geographical barriers. For now the two physiologically divided sections of the species are free to develop independent histories without mutual intercrossing.

Or, to state this suggestion in another way. If the suggestion is well founded, it enables us to regard a large proportion, if not the majority, of natural species as so many expressions of variation in the reproductive systems of their ancestors. When accidental variations of a non-useful kind occur in any of the other systems or parts of an organism, they are, as a rule, immediately extinguished by intercrossing. But whenever they happen to arise in the reproductive system in the way here suggested, they must inevitably tend to be preserved as new natural varieties or incipient species. Once formed as such, the new natural variety, even though living upon the same area as its parent species, will begin an independent course of history; and, as in the now analogous case of isolated varieties, will tend to increase its morphological distance from the parent form, until it eventually becomes a true species. At least it appears to me obvious that in so many cases as variations of the kind in question have taken place, in so many cases must the conditions have been supplied to the formation of new species. Later on I will show in more detail how these conditions have been utilized.

The principle thus briefly sketched in some respects resembles and in other respects differs from the principle of natural selection, or survival of the fittest. For the sake of convenience, therefore, and in order to preserve analogies with already existing terms, I will call this principle Physiological Selection, or Segregation of the Fit.

Arguments à priori.

Before stating the evidence which I have been able to collect of the operation of this principle, it is desirable that I should make one or two general remarks upon the conditions under which alone this evidence can be presented.

First, let it be observed that if this particular kind of variation ever takes place at all, we are not concerned either with its causes or with its degrees. Not with its causes, because in this respect the theory of physiological selection is in just the same position as that of natural selection; it is enough for both that the needful variations are provided, without it being incumbent on either to explain the causes which underlie the variations. Nor is the theory of physiological selection concerned with the degrees of sterility which may in any particular cases have been initially supplied. For, whether the degree of sterility with the parent form is originally great or small, the result of it in the long run will be the same; the only difference will be that in the latter case a greater number of generations would be required in order to separate the varietal from the parent form, as a little thought will be enough to show *.

Next, let it be observed that, from the nature of the case, we cannot expect to meet with much direct evidence of physiological selection yielded by our domesticated varieties. For, first, it has never been the object of breeders or horticulturists to go back to the wild stocks, and therefore observations on this point are wanting; second, breeders and horticulturists keep their strains separate, and many kinds of variation are preserved other than those

* Suppose that, on an average, a cross between the parent and the variety were to yield a progeny of 2, while a cross between two individuals of the new variety were to yield a progeny of 3. In this case there is but a very small degree of sterility towards the parent form; yet if figured out it will be found—supposing this degree of sterility to be inherited by the pure-bred varieties—abundantly sufficient to ensure multiplication of the varietal type, without danger of this type being swamped by the parental.

of the reproductive system with which alone we are concerned, and which must be extremely rare as compared with all the other kinds of variation that it is the aim of breeders and horticulturists to preserve; for, third, it is never the aim of these men to preserve this particular kind of variation. In view of these three considerations, it is clear that we cannot expect to derive much evidence of physiological selection from our domesticated varieties, further than the general proof which these afford of the primary importance of preventing intercrossing with parent forms, if a new varietal form is ever to gain a footing. No one of these domesticated varieties could have been what it now is, unless such intercrossing had been systematically prevented by man; and this gives us good reason to infer that no natural species could have been what it now is, unless every variety in which every species originated had been prevented from intercrossing with its parent form by nature. For we have seen that even if the initial variation, which, as a matter of fact, was in each case preserved, happened to have been useful—and this supposition is, as we have also seen, the reverse of true—it would still be so eminently liable to extinction by intercrossing, that it is at least doubtful whether its preservation could have been secured by natural selection alone. Hence, although we cannot obtain much direct evidence in favour of physiological selection from plants and animals under domestication, we do obtain from them such indirect evidence as arises from proof of the importance of preventing intercrossing with parent forms.

Again, as to plants and animals under nature, the particular variation with which alone we are concerned would probably not be noticed until it had given rise to a new species. In this respect, therefore, the theory of physiological selection is in the same predicament as that of natural selection; in neither case are we able directly to observe the formation of one species out of another by the agency supposed; and therefore in both cases our belief in the agency supposed must, to a large extent, depend on the probability established by general considerations. Nevertheless, although our sources of direct evidence are thus seen to be necessarily limited, I shall now hope to show that they are sufficient to prove the only fact which they are required to prove, namely, that the particular kind of variation which is in question does occur, both in nature and under domestication.

Although, as above remarked, the theory of physiological

selection is not necessarily concerned with the causes of variation in the reproductive system, it will be convenient to classify these causes as extrinsic and intrinsic. By the extrinsic causes I mean changes in the environment which act upon the reproductive system, whether these be changes of food, climate, degree of liberty, and so forth. By intrinsic causes I mean changes taking place in the reproductive system itself of a kind depending on what Mr. Darwin calls "the nature of the organism," or on causes which we are not able to trace, and which may therefore be termed spontaneous.

Now the particular kind of variation the occurrence of which I have to prove is that of impotency—whether absolute or comparative—towards the parent form, without decrease of potency towards the varietal form. One very obvious example of this kind of variation has already been given in the season of flowering or of pairing being either advanced or retarded. This I conceive to be a most important case for us, inasmuch as it is one that must frequently arise in nature. Depending, as it chiefly does, on external causes, numberless species both of plants and animals must, I believe, have been segregated by its influence. For in every case where a change of food, temperature, humidity, altitude, or of any of the other many and complex conditions which go to constitute environment—whether the change be due to migration of the species, or to alterations going on in an area occupied by a stationary species—in every case where such a change either promotes or retards the season of propagation, there we have the kind of variation which is required for physiological selection. And it is needless to give detailed instances of its occurrence where this is due to so well-known and frequently-observed a cause.

But it is in what I have called the spontaneous variability of the reproductive system itself that I mainly rely for evidence of physiological selection. The causes of variability are here far more numerous, subtle, and complex than are such extrinsic causes as those above mentioned; and they are always at work in the reproductive systems of all organisms. Moreover, sensitive as the reproductive system is to small changes in the conditions of life, its spontaneous variability is, as Mr. Darwin has shown, even more remarkable. Now, among all the possible variations of the reproductive system however caused, there is one which, whenever it is produced, cannot be allowed again to disappear;

but must be perpetuated by the ever vigilant agency of physiological selection. What this particular variation is we now know, and I will proceed to give evidence of its spontaneous occurrence, first in individuals, second in varieties, and third in species.

1. *Individuals.*—Mr. Darwin observes:—"It is by no means rare to find certain males and females which will not breed together, though both are known to be perfectly fertile with other males and females. We have no reason to suppose that this is caused by these animals having been subject to any change in their habits of life; therefore such cases are hardly related to our present subject. The cause apparently lies in an innate sexual incompatibility of the pair when matched." He then proceeds to give examples from horses, cattle, pigs, dogs, and pigeons, concluding with the remark that "these facts are worth recording, as they show, like so many previous facts, on what slight constitutional differences the fertility of an animal often depends" *. And in another place he gives references to similar facts in the case of plants †.

Now, if it were needful, I could supply a number of additional cases of this individual incompatibility, or of absolute sterility as between two individuals, each of which is perfectly fertile with all other individuals ‡. But I think that the not unusual occurrence of this fact will be regarded as abundantly substantiated by these references.

And here, it appears to me, we have a most significant piece of evidence upon the origin of species. If even as between two individuals there may thus arise absolute sterility, without there being in either of them the least impairment of fertility with other individuals, is it not obvious that we have precisely the kind of variation which my theory requires, and that we have this variation spontaneously or suddenly given in the highest possible degree of efficiency? Shallow criticism might reply that this is the precise opposite of the variation which my theory requires; and under one point of view such is the case. For here we have

* 'Variation,' &c., vol. ii. pp. 145–6. † 'Origin of Species,' ed. 6, p. 246.

‡ I may remark that individual incompatibility is especially apt to declare itself when the individuals paired belong to different species. That is to say, while some individuals taken from the two species will readily produce hybrids, other individuals taken from the same species will prove hopelessly sterile. The same applies to the fertility of hybrids. These facts are of some additional importance to us, because they occupy a kind of intermediate position between these given above and those given in the next succeeding paragraphs.

sterility towards the varietal form, with unimpaired fertility towards the parent form. But a little thought will show that this criticism would be shallow. The important fact is that among a number of individuals of the same species, all exposed to apparently the same conditions of life, some of the number so far deviate from the specific type in respect of their reproductive systems as to be absolutely sterile with certain members of their own species, while remaining perfectly fertile with other members. In terms of the above criticism, therefore, this fact might be translated into saying that if the reproductive system can be proved to undergo so remarkable a variation as that of *individual* incompatibility, much more is it likely to undergo the "opposite" variation, wherein a similar incompatibility would extend to a larger number of individuals. For certainly the most remarkable feature about this individual incompatibility is the fact of its being only individual. It would not be nearly so remarkable, or physiologically improbable, that such incompatibility should run through a whole race or strain. Therefore, the fact of individual incompatibility appears to me to furnish most important evidence of my theory; for it proves that even the most apparently capricious and wholly unaccountable variations may spontaneously arise within the limits of the reproductive system—variations which, physiologically considered, are much more remarkable, or antecedently improbable, than anything that my theory requires.

2. *Races.*—But of even more importance to us is the direct evidence of such a state of matters in the case of varieties, breeds, or strains. Incompatibility between individuals is, indeed, of very great importance to my theory, because it constitutes the first link in a chain of direct evidence as to the actual occurrence of the particular kind of variation on which the theory depends; here we have, as it were, the first beginning in an individual organism of a change which, under suitable conditions, may give rise to a new strain, and so eventually to a new species. But, seeing that the individual is so small a constituent part of his species, unless his peculiar incompatibility has reference to the majority of other individuals, so that it becomes only the minority of the opposite sex with whom he can pair, the probability is that the peculiar condition of his reproductive system would not be perpetuated by heredity, but would become extinguished by intercrossing. As I have already said, it is, physiologically considered, even more remarkable that such

incompatibility should ever be exclusively individual than that it should be racial; and therefore, as likewise remarked, I regard these cases of individual incompatibility as of value to my theory chiefly because they prove the actual occurrence of the variation which the theory requires, and this as suddenly or spontaneously arising in the highest degree of efficiency. But I will now adduce evidence to show that a state of matters more or less similar may be proved to obtain throughout a whole breed or strain, so that we then have, not merely individual incompatibility, but what may be termed racial incompatibility; and therefore that we are on the highroad to the branching-place of a new species. Here I will again quote my facts from Darwin, partly because he has so profoundly studied the subject of variation, but chiefly because, wherever it is possible, I desire to rely upon his authority.

In the ninth chapter of the 'Origin of Species,' and in the nineteenth chapter of the 'Variation of Plants and Animals under Domestication,' Mr. Darwin adduces miscellaneous evidence of the fact that in many cases varieties of the same species exhibit a higher degree of fertility within themselves than they do with one another. In this respect, therefore, they resemble natural species. Inasmuch, however, as they are not natural species, but domesticated varieties (or the changed descendants of one natural species), they are here available as evidence to prove what I have just called racial incompatibility, due to the change which has been effected in their reproductive systems. It makes no difference whether we regard this change as due to intrinsic or to extrinsic causes; in either case the racial incompatibility is the same, and this is all that the theory of physiological selection requires. Take, for example, the following case which, as Mr. Darwin says, "is the result of an astonishing number of experiments made during many years on nine species of *Verbascum*, by so good an observer and so hostile * a witness as Gärtner: namely, that the yellow and white varieties when crossed produce less seed than the similarly coloured varieties of the same species;" and elsewhere he quotes a statement from the same authority to the effect that the blue and red varieties of the pimpernel are absolutely sterile together, while each is perfectly fertile within itself. So that in these cases we have a marked degree of racial incompatibility between

* "Hostile" because Gärtner believed that the distinction between species and varieties in respect of sterility is more absolute than Darwin believed.

yellow and white varieties, or between blue and red varieties of the same species, while each continues fertile within its own limits. And similarly in all the other cases.

Now, in these facts one may only see evidence of changes in the organism reacting on the reproductive system in such a way as to produce this particular effect. I shall have more to say on this subject later on; here it is enough to remark that it matters little to my theory whether the changes be thus due to reaction on the reproductive system, or have arisen in the reproductive system, as it were, independently; for, as above observed, whether the causes of the change be supposed intrinsic or extrinsic, the change itself is really all that we are now concerned with. This change, however produced, is a change in the direction of what I call racial incompatibility, and therefore, if it had taken place in any wild species, must necessarily have constituted a physiological barrier to intercrossing between the two varieties, which, according to my theory, is the primary condition required for the development of varieties into species. And that such a state of matters is at least as likely to occur in a wild species as in a domesticated descendant is obvious. For domestication, as a rule, increases fertility, and therefore is, as a rule, inimical to sterility, sometimes even breaking down the physiological barriers between natural species. Therefore, if at other times even under domestication the reproductive system may vary so as to erect these barriers between artificial varieties, much more are such barriers likely to be erected between varieties when these arise in a state of nature. Indeed, the difficulty is to find such cases in a state of domestication, the great difference between mongrels and hybrids consisting in this very fact of the former being so usually fertile, and the latter so usually sterile. But I trust that enough has now been said to show that even among our domestic productions we may find evidence of racial incompatibility, or of that particular variation in the reproductive apparatus which is required by the theory of physiological selection.

As regards varieties in a state of nature, it must be noticed, first of all, that racial incompatibility is not likely to be observed. For, on the one hand, if such incompatibility is in any degree pronounced, for this very reason the two forms would be ranked by naturalists as distinct species; while, on the other hand, if not so pronounced, the fact of incompatibility could only be revealed by careful observation. For these reasons the evidence which I

have to give of incompatibility in a state of nature is derived chiefly from species, as I will now explain.

3. *Species.*—According to the general theory of evolution, which in this paper is taken for granted, the distinction between varieties and species is only a distinction of degree; and the distinction is mainly, as well as most generally, that of mutual sterility, whether absolute or partial. Therefore I am here supplied with an incalculable number of instances, all tending to support my theory; for in so many instances as variation has led to any degree of sterility between parent and varietal forms, or between the varying descendants of the same form, in so many instances it is a simple statement of fact to say that physiological selection must have taken place. There remains, however, the question whether the particular change in the reproductive system, which led to all these cases of mutual sterility, was anterior or posterior to changes in other parts of the organisms. For, if it was anterior, these other changes—even though they be adaptive changes—were presumably due to the sexual change having interposed its barrier to crossing with parent forms; while, if the sexual change were posterior to the others, the presumption would be that it was those other changes which, by their reaction on the reproductive system, induced the sexual change. I shall have to consider this alternative later on. Meanwhile, therefore, it is enough to point out that under either possibility the principles of physiological selection are present; only these principles are accredited with so much the more causal influence in the production of species in the proportion that we find reason to suppose the sexual change to have been, as a rule, the prior change. Hence, under either alternative, and on the datum that species are extreme varieties, we have presented many millions of instances of fertility within the varietal form, with sterility towards allied forms. Why, then, should we feel any difficulty in supposing that the same thing happens in a lesser degree? Nay, rather, would it not be a most extraordinary fact if it did never happen in lesser degrees? Yet, if it does ever happen in lesser degrees, we have a variation of the kind required by physiological selection, although not yet of a degree sufficient to constitute the variety a new species—seeing that species is practically a name reserved by naturalists to designate this particular kind of variation, when it has arrived at a certain observable degree of departure from the parent form.

This way of looking at the matter may perhaps be rendered more effective if we glance for a moment at the extraordinary differences in the degrees of sterility which are manifested by variations that have gone far enough to be ranked by naturalists as undoubted species. For in this way we can see how impossible it is to lay down any hard and fast distinctions between species and varieties in respect of sterility, even though it has always been the aim of naturalists to give primary importance to this point. Now this difficulty is just what we ought to find, according to my theory, as a very few words will be enough to show. For, even if allied forms were always closely contiguous forms, we should expect on this theory that great differences in the degrees of sterility should be manifested by different species. According to this theory, species are but records of a sufficient degree of sterility having arisen with parent forms to admit of the varietal form not becoming swamped by intercrossing. Now, the degree of sterility required for this purpose would not be the same in all cases, seeing that in some cases other conditions might be present to assist in the prevention of intercrossing, as we shall see later on. Moreover, in other cases the initial (or the subsequently induced) degree of sterility may have been greater than was required to effect the physiological separation that took place. Lastly, when to these considerations we add that allied species are not always necessarily contiguous species, and therefore need never have had any opportunity of intercrossing (having originated independently from the same parent form in different localities)—when we consider all these things, we should expect to find the degrees of sexual incompatibility between species highly variable. Or, in other words, we should expect to find that the extreme varieties called species should not exhibit an equal degree of incompatibility in all cases. And this is just what we do find; or, as Mr. Darwin puts it, "the sterility of various species when crossed is so different in degree, and graduates away so insensibly, and, on the other hand, the fertility of pure species is so easily affected by various circumstances, that for all practical purposes it is most difficult to say where perfect fertility ends and sterility begins."

But not only so. Among all the varieties in nature which are extreme enough to be ranked as species, we might expect, upon the theory of physiological selection, that some should have developed sterility towards certain of their allies, while develop-

ing an even increased degree of fertility towards others. For in all cases, according to this theory, degrees of fertility between allied forms are, so to speak, matters of accident; and it is only when variations in the direction of sterility with allied forms (parental or otherwise) are sufficiently pronounced to prevent intercrossing that the forms in question rise to specific rank. Therefore, looking to the immense number of species, we might expect that in some few cases where the allied forms are not also contiguous, the variation in the reproductive system which rendered one of the forms sterile with its parent form, should not also have rendered it sterile with exotic forms, or even that it should be more fertile with them than with itself. And this we do occasionally find to be the case, as the following quotations from Darwin will show.

"Of his [Herbert] many important statements I will here give only a single one as an example, namely, that "every ovule in a pod of *Crinum capense* fertilised by *C. revolutum* produced a plant, which I never saw to occur in a case of its natural fecundation." So that here we have perfect, or even more than commonly perfect, fertility in a first cross between two distinct species"*.

Mr. Darwin then proceeds to give other and analogous cases as having been well observed in *Lobelia*, *Verbascum*, and *Passiflora*; and then adds, "In the genus *Hippeastrum*, in *Corydalis* as shown by Professor Hildebrand, in various orchids as shown by Mr. Scott and Fritz Müller, all the individuals are in this peculiar condition. So that with some species, certain abnormal individuals, and in other species all the individuals, can actually be hybridised much more readily than they can be fertilised by pollen from the same individual plant."

Now, these and all other such facts go to prove that, notwithstanding even a specific distinction, there may be a higher degree of compatibility between the sexual elements of the different forms than between the sexual elements of the same form; and this would show that in the matter of sexual compatibility more depends upon the nature of the sexual elements than depends upon the rest of the organism. In other words, we may here regard the two distinct species as (physiologically considered) extreme varieties, and thus we should have evidence of a higher degree of fertility between these two extreme varietal forms than

* 'Origin of Species,' ed. 6, p. 238; also see 'Variation,' vol. ii. pp. 143–4.

normally occurs within each parent form. When, for instance, we are told by Gärtner that the yellow and white varieties of one species of *Verbascum* are considerably more fertile with the similarly coloured varieties of distinct species than they are with the differently coloured varieties of the same species, we can only conclude that the state of the reproductive system is such that there is a higher degree of sterility—or a lesser degree of sexual affinity—within the limits of the parent form, than there is between it and another variety so far changed as to constitute a distinct species. I do not, of course, pretend that in these cases the species towards which the increased fertility is exhibited has been separated from the other by physiological selection. Indeed, to do this would be to prove too much, because if the separation had been effected by physiological selection, there ought as a result to be increased sterility, and not increased fertility between these two particular specific forms. But I adduce these facts as forcible evidence of physiological selection, because they show, in the strongest imaginable way, that the conditions of sexual affinity which are required for physiological selection are to be found even between varieties so widely separated as to constitute true species. For if these conditions of sexual affinity may be such that an organism is actually more fertile with members of a distinct species than it is with members of its own species, much more may an organism which has become infertile with its parent form continue fertile with itself. In the cases mentioned the individual sexual organs may be regarded as relatively sterile towards their parent, *i. e.* their own specific form, while relatively fertile towards another specific form. Much more then may an individual be relatively sterile towards its parent form, while relatively fertile towards its own varietal form.

The same argument may be adduced from the case of animals. There are many recorded instances of both birds and mammals which, when under confinement, have proved themselves more fertile with members of different species than with members of their own. Now, whether this state of matters be supposed to be normal or superinduced by changes in the conditions of life, in either case we have organisms which are relatively sterile towards their own parent form, or relatively fertile towards another varietal form so different as to constitute a distinct species. As in the similar case of the plants above mentioned, therefore, we may here repeat how much more probable than

this would be the case that is required by physiological relation—namely, a variety relatively sterile towards its parent form, while relatively fertile within itself.

These anomalous cases, however, have only been given to show the highly variable and capricious character of the reproductive system both in plants and animals; and hence to show that the much less remarkable kind of variation which is required by my theory is not antecedently improbable. But, as a matter of argument, I do not require these anomalous cases; for enough has been previously said to prove that the particular kind of variation required actually does occur as between individuals, between races, and between species. Nevertheless, for the sake of adducing yet one further argument of an *à priori* kind, I may notice the very general fact that different varietal characters in parents belonging to the same species persistently refuse to blend in the offspring. This, indeed, may be said to be the rule both in plants and animals *. But the varietal character with which we are concerned belongs to the reproductive system itself, independently of any other part of the organism. Therefore, if this variation follows the rule of variations in general, there must be more difficulty in its blending with the parent (or unchanged) form than there is in its blending with other similarly changed forms. But, in this particular case, failure to blend means failure to propagate—*i. e.* sterility, whether partial or absolute. The varietal form will thus be more fertile within itself than it is towards its parent stock.

Arguments à posteriori.

Hitherto the evidence which I have adduced in favour of physiological selection as an agency in the evolution of species is only *prima facie*. That is to say, although we have evidence to show the occurrence of this particular kind of variation, and although we can see that whenever it does occur it must be preserved, as yet we have had no evidence to indicate to what extent this particular kind of variation has been at work in the formation of species. Thus far all I have been endeavouring to show is that we have many and weighty considerations of an *à priori* kind whereby to render the theory of physiological selection

* See, for example, 'Variation of Plants and Animals under Domestication,' vol. ii. p. 72.

antecedently probable. I will, therefore, next proceed to state such evidence as I have been able to collect, tending to show that the facts of organic nature are such as we should expect they ought to be, if it is true that physiological selection has played a considerable part in their causation. And to do this I will begin by taking the three cardinal objections to the theory of natural selection with which I set out, namely sterility, intercrossing, and inutility. For, as we shall see—and this in itself is a suggestive consideration—all the facts which here present formidable obstacles to the theory of natural selection are not only explained by the theory of physiological selection, but furnish to that theory some of the best evidence which I have been able to find.

Argument from Sterility between Species.

As now repeatedly observed, the theory of natural selection is not, properly speaking, a theory of the origin of species: it is a theory of the development of adaptive structures. Only if species always differed from one another in respect of adaptive structures would natural selection be a theory of the origin of species. But, as we have already seen, species do not always, or even generally, thus differ from one another. In what, then, do they differ? They differ, first, chiefly and most generally, in respect of their reproductive systems; this, therefore, I will call the primary difference. Next, they differ in an endless variety of more or less minute details of structure, which are sometimes of an adaptive character, and sometimes not. These, therefore, I will call secondary differences. Now, these secondary differences, or differences of minute detail, are never numerous as between any two allied species; in almost all cases they admit of being represented by units. Yet, if it were possible to enumerate all the specific differences throughout both the vegetable and animal kingdoms, there would be required a row of figures expressive of many millions. Or, otherwise stated, the secondary features which serve to distinguish species from species are minute differences of structure, sometimes useful and sometimes not, which may occur in any parts of organisms, but which never occur in many parts of the same organism. Thus we perceive that, if we have regard to the whole range of species, what I call the secondary differences are in the highest imaginable degree variable or inconstant. The only distinction which is at all constant or general is the one which I call primary, or the one which belongs

exclusively to the reproductive system. Surely, therefore, what we first of all require in a theory of the origin of *species* is an explanation of this relatively constant or general distinction. But this is just what all previous theories fail to supply. Natural selection accounts for some among the many secondary distinctions; but is confessedly unable to account for the primary distinction. The same remark applies to sexual selection, use and disuse, economy of growth, correlated variability, and so forth. Even the prevention of intercrossing by geographical barriers is unable to explain the very general occurrence of some degree of sterility between two allied varieties, which have diverged sufficiently to take rank as different species. All these theories, therefore, are here in the same predicament: they profess to be theories of the origin of species, and yet none of them is able to explain the one fact which more than any other goes to constitute the distinction between species and species. The consequence is that most evolutionists fall back upon a great assumption: they say it must be the change of organization which causes the sterility; it must be the secondary distinctions which determine the primary. But the contrary proposition is surely at least as probable, namely, that it is the sterility which, by preventing intercrossing with parent forms, has determined the secondary distinctions; or, rather, that this has been the original condition to the operation of the modifying causes in all cases where free intercrossing has not been otherwise prevented. For, obviously, it is a pure assumption to say that the secondary differences between species have been historically prior to the primary difference, and that they stand to it in the relation of cause to effect. Moreover, the assumption does not stand the test of examination, as I will now proceed to show.

First, on merely *à priori* grounds, it scarcely seems probable that whenever any * part of any organism is slightly changed in any way by natural selection or any other cause, the reproductive system should forthwith respond to that change by becoming sterile with allied forms. What we find in nature is a more or less constant association between the one primary distinction and an endless profusion of secondary distinctions. Now, if this association had been between the primary distinction and some one, or even some few, secondary distinctions, constantly the

* This appears to be what the theory requires, seeing that *all* parts of organisms are subject to secondary specific distinctions.

same in kind, in this case I could have seen that the question would have been an open one as to which was cause and which effect, or which was the conditional and which the conditioned. But, as the case actually stands, on merely antecedent grounds it does not appear to me that the question is an open one. Here we have a constant peculiarity or condition of the reproductive system, repeated over and over again millions of times, throughout organic nature past and present; and we perpetually find that when this peculiar condition of the reproductive system occurs it is associated with structural changes elsewhere, which, however, may affect any part of any organism, and this in any degree. Now, I ask, is it a reasonable view to imagine that the one constant peculiarity is always the result and never the condition of any among these millions of inconstant and organically minute changes with which it is found associated? Even if I had no theory whereby to account for the primary and constant distinction being also the primordial and conditioning distinction, on merely *à priori* grounds I should feel convinced that in some way or another it *must* be so.

But, secondly, quitting *à priori* grounds, it is a matter of notorious fact that in the case of nearly all our innumerable artificial productions, organisms admit of being profoundly changed in a great variety of ways, without any reaction on the reproductive system following as a consequence. So seldom, indeed, does any such reaction follow from what may be termed all these innumerable experiments upon the subject, that Mr. Darwin was obliged to explain the discrepancy between the known influence of artificial selection and the supposed influence of natural selection by invoking a wholly independent, an extremely hypothetical, and, to my mind, a most unsatisfactory principle. This principle—*i. e.* that of prolonged exposure to similar conditions of life—I have already considered, and shown why it appears to me the feeblest suggestion that is to be met with in the whole range of Mr. Darwin's writings.

Thirdly, as regards wild species, Mr. Darwin shows that "the correspondence between systematic affinity and the facility of crossing is by no means strict. A multitude of cases could be given of very closely allied species which will not unite, or only with extreme difficulty; and, on the other hand, of very distinct species which unite with the utmost facility." And he goes on to show that "within the limits of the same family, or even of

the same genus, these opposite cases may occur"*. Now, on the supposition that sterility between species is always or generally caused by the indirect influence on the reproductive system of changes taking place in other parts of the organism, these facts are unintelligible—being, indeed, as a mere matter of logic, contradictory of the supposition.

Fourthly, it is surely a most significant fact that, as Mr. Darwin observes, "independently of the question of fertility, in all other respects there is the closest general resemblance between hybrids and mongrels" †. For this fact implies that natural selection and artificial selection run perfectly parallel in all other respects, save in the one respect of reacting on the reproductive system, where, according to the views against which I am arguing, they must be regarded as differing, not only constantly, but also profoundly.

Fifthly, and lastly, Darwin further observes that "the primary cause of the sterility of crossed species (as compared with crossed varieties) is confined to differences in their sexual elements" ‡. Now this assuredly proves that the primary specific distinction is one with which the organism as a whole is not concerned; this primary distinction is, so to speak, a local variation in the organism, which has to do only with the reproductive system, and which therefore need not necessarily be in all, or even in most, cases an incidental result of minute variations going on elsewhere.

In view of these several considerations, it appears to me perfectly plain that the smaller organic changes which alone are concerned in specific distinctions are not always, or even generally, adequate to react on the reproductive system

* He also adds:—"No one has been able to point out what kind or amount of difference in any recognizable character is sufficient to prevent two species crossing. It can be shown that plants most widely different in habit and general appearance, and having strongly marked differences in every part of the flower, even in the pollen, in the fruit, and in the cotyledons, can be crossed. Annual and perennial plants, deciduous and evergreen trees, plants inhabiting different stations and fitted for extremely different climates, can often be crossed with ease." And, after considering the further case of reciprocal crosses, he expresses the general conclusion: "Such cases are highly important, for they prove that the capacity in any two species to cross is often completely independent of their systematic affinity, that is of any difference in their structure or constitution, excepting in their reproductive systems." ('Origin of Species,' ed. 6, p. 243.)

† 'Origin of Species,' where the general fact is proved beyond question.

‡ *Loc. cit.* This fact, also, is proved beyond the possibility of question.

in the way hitherto supposed by evolutionists *; but that the primary distinction is in most cases, as I have just expressed it, a local variation in the organism, which has to do only with the reproductive system. Why, then, should we suppose that it differs from a local variation taking place in any other part of the organism? Why should we suppose that, unlike all other such variations, it cannot be independent, but must be superinduced as a secondary result of variations taking place elsewhere? It appears to me that the chief reason why evolutionists suppose this, is because the particular variation in question happens to have as its result the origination of species; and that, being already committed to a belief in other agencies as the cause of such origination, in consistency they are obliged to regard this particular kind of local variation as not independent, but superinduced as a secondary result of these other agencies operating on other parts of the organism. In short, it appears to me that by persistently regarding the primary specific distinction as a derivative and incidental result of the secondary, evolutionists are putting the cart before the horse; and the only reason they can show for choosing this arrangement is that they already assume the origin of species to have been due to other causes, and in particular to natural selection. But once let them clearly perceive that natural selection is concerned with the origin of species only in so far as it is concerned with the origin of adaptive structures, or only in so far as it is concerned with some among the many secondary distinctions—once let naturalists be perfectly clear upon this point, and they will perceive that the primary specific distinction takes its place beside all other variations as a variation of a local character, which may, indeed, at times be due to the indirect influence of natural selection, use, disuse, and so forth; but which may also be due to any of the other numberless and hidden causes that are concerned with variation in general.

Thus, I repeat, what we require in a theory of the origin of species is a theory to explain the primary and most constant distinction between species, or the distinction in virtue of which they exist as species. This distinction, as we have now so repeatedly seen, is one that belongs exclusively to the reproductive system; and it always consists in comparative sterility towards

* I do not think that Mr. Darwin himself entertained this supposition, and therefore I have not his authority against me.

allied forms, with continued fertility within the varietal form. Now, this state of matters as between allied species is merely an intensification, or a further development, of that which physiological selection supposes to obtain between the physiological varieties, where the variation is from the first in the direction just mentioned. That this initial variation should afterwards become intensified by the practical separation of the two varieties, so that what began as a varietal difference ends as a specific difference, is no more than we should expect. For from the first the variation was one specially affecting the reproductive system in the special way required; intercrossing with the parent form was from the first precluded in a degree proportional to the amount of the variation. The species was thus from the first divided into two physiological parts, each of which then entered upon an independent course of genetic history; the principle of continued variation along the same lines would tend to increase the original separation; the new variety, therefore, besides having been thus started with a tendency, and a probable increasing tendency, to a physiological separation from its parent stock, must afterwards have become exposed to all or any such modifying causes as are found to produce a similar separation in a portion of a species when started on an independent course of history by migration or by geographical isolation.

Lastly, over and above all these considerations, there remains one of much importance, not only to the present division of my argument, but to my theory as a whole. For Mr. Darwin has furnished exceedingly good reasons for entertaining his own view that this is "one of the causes of ordinary variability; namely, that the reproductive system, from being eminently sensitive to changed conditions of life, fails under these circumstances to perform its proper function of producing offspring closely similar in all respects to the parent form" *. Now, if this view is well founded—and, as I have said, Mr. Darwin's arguments in favour of it are most cogent—it obviously has most important bearings on the present theory; for it implies that whenever the reproductive system undergoes a variation on its own account, whether this be due to extrinsic or intrinsic causes, it is apt to induce variations in other parts of progeny. Hence, prevention of intercrossing by the physiological barrier of reproductive or primary variation is so far more likely to be followed

* 'Origin of Species,' ed. 6, p. 260.

by secondary variations than when the prevention of intercrossing arises from geographical barriers or from migration. For in this case, over and above the influence of independent variability, there is a direct causal connection between the agency which prevents intercrossing and the subsequent production of secondary specific characters. So that, if Mr. Darwin's view of one of the causes of variability be accepted, it follows that wherever the primary specific distinction of sterility arises, there it is to be expected that an unusual crop of variations should follow by way of consequence in other parts of the physiologically separated progeny—variations, therefore, which, whether they happen to be useful or unuseful, appear under circumstances most favourable to their perpetuation as secondary specific characters.

I trust, then, that sufficient reasons have now been given to justify my view that, if we take a broad survey of all the facts bearing on the question, it becomes almost impossible to doubt that the primary specific distinction is, as a general rule, the primordial distinction. I say "as a general rule," because the next point which I wish to present is that it constitutes no part of my argument to deny that in some, and possibly in many, cases the primary distinction may have been superinduced by the secondary distinctions. Indeed, looking to the occasional appearance of partial sterility between domesticated productions, as well as to the universally high degree of it between genera, and its universally absolute degree between families, orders, and classes, I see the best of reasons to conclude that in some cases the sterility between species may have been originally caused, *and in a much greater number of cases subsequently intensified*, by changes going on in other parts of the organism. Moreover, I doubt not that of the agencies determining such changes, natural selection is probably one of the most important. In other words, I do not doubt that natural selection, by operating independently on a separated portion of a species—whether the separation be physiological or geographical—may often help to induce sterility with the parent form, by indirectly modifying the reproductive system through changes which it effects in other parts of the organism; and I see no reason to doubt that the same is true of sexual selection, use and disuse, economy of growth, correlated variability, or any other cause tending to modify the organism in any of its parts, and so, in *some* instances, reacting indirectly on the reproductive system in the way required. Here I only

differ from other evolutionists in refusing to suppose that this must invariably, or even generally, be the result of what I may term adaptational causes, when these are producing small (*i. e.* specific) morphological changes in any part of any organism. Yet, as I have said, I doubt not that such has been the incidental or indirect result of these causes in some minority of cases. But, now, what does this amount to? It amounts to nothing more than a re-statement of the theory of physiological selection. It merely suggests hypothetically the cause, or causes, of that particular variation in the reproductive system with which alone the theory of physiological selection is concerned, and which, as a matter of fact, *however caused*, is found to constitute the one cardinal distinction between species and species. Therefore I am really not concerned with what I deem the impossible task of showing how far, or how often, natural selection, or any other cause, may have induced this particular kind of variation in the reproductive system by its operations on other parts of an organism. Even if I were to go the full length that other evolutionists have gone, and regard this primary specific distinction as in all cases due to the secondary specific distinctions, still I should not be vacating my theory of physiological selection; I should merely be limiting the possibilities of variation within the reproductive system in what I now consider a wholly unjustifiable manner. For, as previously stated, it appears to me much the more rational view that the primary specific distinction is likewise, as a rule, the primordial distinction, and that the cases where it has been superinduced by the secondary distinctions are comparatively few in number.

Next, let it be observed that, even in these last-mentioned cases—whether, as I believe, they are comparatively few or comparatively numerous—where the primary distinction has been superinduced by the secondary, even in these cases my theory is available to show why the two kinds of distinction are so generally associated, or why it is that the primary distinction is so habitual an accompaniment of the secondary distinctions, of whatever kinds or degrees the latter may happen to be. For, according to my theory, the reason of the association in these cases is that it can only be those kinds and degrees of secondary distinction which are able so to react on the reproductive system as to induce the primary distinction that are *for this reason* preserved, or allowed to become developed as a new specific type. Whether as causes or as effects, therefore, the secondary distinctions are *dependent*

on the primary one, in the sense that, even if they be the causes, they depend for their existence on the fact that they happen to have been capable of producing this particular effect—a general view of the case which appears to me abundantly justified by the fact of their general *association*. Hence, if there are any cases—and I do not doubt that there are many—where the secondary distinctions have been the cause of the primary distinction, still even here the former are, as I have phrased it, dependent on the latter, inasmuch as the latter is a necessary condition to their existence. Or, otherwise expressed, unless the secondary distinctions had happened to be of a kind which induced the primary distinction, they could not in themselves have survived, but would have been reabsorbed by free intercossing. Thus, according to my view, even in the minority of cases where the causes of the primary distinction have been such changes in the organism as I have called secondary distinctions, even in this minority of cases the principles of physiological selection have been at work. For these principles have in all those cases *selected* the particular kinds of secondary distinctions which have proved themselves capable of so reacting on the reproductive system as to bring about the primary distinction.

Suppose, for instance, that all our horticulturists and breeders were suddenly to allow all domesticated varieties freely to intercross, and suppose that some of these varieties had been previously acted upon by artificial selection to an extent of inducing sterility in a degree comparable with what evolutionists imagine that natural selection may have been able to accomplish in incipient species. Under these circumstances, physiological selection would at once set to work to pick out all these sexually protected forms, and hand them on as permanent varieties (or, if the sterility were sufficiently pronounced, as true species); while all the other forms, no matter how much they might differ from one another in respect of secondary distinctions, would be doomed to extinction—or, as we should then say, to reversion, which merely means reabsorption of secondary distinctions into parent forms. Now, if so soon as the artificial barriers to intercrossing were removed this is what would inevitably take place even with secondary distinctions already formed, is it not evident that, in the original absence of any kind of barrier otherwise given, none of these secondary distinctions could ever have arisen, except those

which happened so to react on the reproductive system as themselves incidentally to erect a barrier, which might then serve—as in the parallel case given in my illustration—to protect that particular assemblage of secondary distinctions from extermination when they first arose, and afterwards to admit of their being handed on in ever-increasing degrees of development? And, in point of fact, that this has been the case (supposing for illustration's sake the primary to have *always* been the result of secondary distinctions) is proved by the very general association that is now found to subsist between them—an association which can only be accounted for by supposing that all other kinds of secondary distinction failed in what may be termed their struggle for existence, simply because they were not able to rear for themselves this barrier of sterility.

Thus, we see, it really makes no essential difference to my theory whether it be supposed, in any given case, that the primary distinction was prior or subsequent to the secondary distinctions. I have given my reasons for believing that in the great majority of cases the primary distinction was, as I have said, the primordial distinction; and, if so, the causal influence of physiological selection in the formation of species was in these cases absolute. But I have also given my reasons for believing that in a minority of cases the secondary distinctions determined the primary distinction; and, if so, the causal influence of physiological selection was in these cases relative, or conditional on other causes extrinsic to the organism. But whether the ultimate causes of the primary distinction be extrinsic or intrinsic, and whether this primary distinction be historically prior or subsequent to the secondary distinctions, in all cases (save where intercrossing is otherwise prevented) it must be physiological selection that has been the agency to which the preservation of the secondary distinctions has been due. For, as we have now so repeatedly seen, any secondary distinctions, howsoever useful in themselves, must be always liable to extinction almost at the moment of their birth, unless they happen to be protected by the primary distinction. Hence, whether the latter be given by independent variation on the part of the reproductive system itself, or as an indirect and concomitant result of variations taking place elsewhere, it is equally true that the principles of physiological selection have been at work; and, therefore, that it is to those

principles we must look for our ultimate explanation of the origin of species *.

If we thus regard sterility between species as the result of what I have called a local variation arising only in the reproductive system, whether induced by changes taking place in other parts of the organism, to changes in the conditions of life, or to changes inherent in the reproductive system itself, we can understand (*a*) why such sterility rarely, though sometimes, occurs in our domesticated productions; (*b*) why it so generally occurs in some degree between species; and (*c*) why as between species it occurs in all degrees.

(*a*) It rarely occurs in our domesticated productions, because it has never been the object of breeders or horticulturists to preserve this kind of variation. Yet it sometimes does occur in some degree among our domesticated productions, because the changes produced on other parts of the organism by artificial selection do, in a small percentage of cases, react upon the reproductive system in the way of tending to produce sterility with the parent form, without lessening fertility with the varietal form. Again (*b*), this particular condition of the reproductive system is so generally characteristic of species, simply because, as a general rule, it is owing to this condition that species exist as species; any variation, therefore, towards this condition, howsoever produced, must always have been preserved by physiological selection, with the result of a new specific form to record the fact. And, lastly (*c*), this particular variation in the reproductive system has taken place under nature in such a number of degrees, from absolute sterility between species up to complete, or even to more than complete fertility, because natural species, while being records of this particular *kind* of variation, are likewise the records of all *degrees* of such variation which have proved sufficient to prevent overwhelming intercrossing with parent forms. Sometimes this degree has been less than others, because other conditions—climatic, geographical, habitational, physiological, and even psychological—have co-operated to prevent intercrossing, or even to

* In order to avoid needlessly confusing the foregoing argument, I have omitted to notice that geographical barriers serve the same function as physiological barriers; and also that secondary distinctions caused by use and disuse do not require to be protected from the levelling effects of intercrossing. But, as will be seen from the next succeeding paragraphs, these considerations are in no way opposed to my theory.

render the prevention of intercrossing wholly unnecessary, and thus not in any way to require the protecting influence of physiological selection. I will consider these points separately.

First, other conditions may co-operate with physiological selection to prevent intercrossing with parent forms, and therefore, in whatever degree such co-operation is furnished, a correspondingly less degree of sterility will be required in order to secure a differentiation of specific type. Of these other conditions migrations and geographical barriers are probably the most important; and as such barriers may occur in all degrees of efficiency, from wholly secluding small sections of species in oceanic islands to imposing but slight difficulties in crossing streams &c., it is evident that in many cases physiological selection may be thus assisted in a great variety of degrees. Again, even where there are no geographical barriers of any kind, varieties will occasionally be segregated by their different degrees of adaptation to differences of climate—the adaptation having no special reference to the reproductive system, and yet, by determining that the variety shall live under a different climate from the parent form, more or less effectually preventing intercrossing with that form. The same thing applies to varieties occupying stations of their own*, and also, in the case of higher Vertebrata, to all the members of the same variety preferring to pair together, rather than with their parent form, or with other varieties †. In all these cases where the principles of physiological selection have been in any degree accidentally assisted by other conditions, a correspondingly less degree of variation in the reproductive system would have been needed to differentiate the species. That is to say, if the variation has been sufficient in amount, or in relation to all the other conditions of the time, to prevent intercrossing with the parent form in any extinguishing degree, the resulting sterility need not always be absolute, even as between compatriots, but may occur in any corresponding degree; while, as between species which have been independently evolved on different geographical areas, fertility may remain unimpaired, or even be accidentally increased.

Secondly, in other cases species may have become differentiated without the variations requiring to be protected from intercrossing, either by physiological, geographical, or any other barriers. In these cases, therefore, physiological selection has had no part in

* See 'Origin of Species,' ed. 6, p. 8.

† Ibid.

the evolution of species. The cases to which I allude are those where specific types have been modified by the agencies of what Mr. Spencer calls "direct equilibration." Of these agencies the most important that happen to be known to us are use and disuse. A little thought will show that the moulding power of these agencies on specific types must be quite as independent of physiological selection as it is of natural selection. But a little more thought will show that this moulding influence must always be in some one line of morphological change: it cannot proceed in many diverging ways at once; but must slowly transmute a whole specific type into some other specific type. Now, if this change should happen to go on in a portion of a species living in one part of the world, when that portion becomes transmuted into a different specific type, there is no reason why the now modified descendants should prove barren when crossed with their unchanged, or differently changed, parent-form, which may be still living in any other part of the world.

In view of all these considerations, I should regard it as a serious objection to my theory if it could be shown that sterility between allied species is invariably absolute, or even if it could be shown that there are no cases of fertility unimpaired. What my theory would expect to find is exactly what we do find, namely, a considerable majority of instances where sterility occurs in all degrees, with comparatively exceptional instances where secondary distinctions have been able to develop without being associated with the primary distinction.

On the whole, therefore, I cannot but candidly consider that all the facts relating to the sterility of natural species are just what they ought to be, if they have been in chief part due to the principle which I am advocating. Mr. Darwin appears to have clearly perceived that there must be some one principle serving to explain all these facts, so curiously related and yet so curiously diverse; for he says, and he says most truly, "We have conclusive evidence that the sterility of species must be due to some principle quite independent of natural selection." And I trust enough has now been said to show that, in all probability, this hitherto unnoticed principle is the principle of physiological selection.

Argument from the Prevention of Intercrossing.

This argument is the same from whatever cause the prevention of intercrossing may arise. Where intercrossing is prevented by

geographical barriers or by migration, it is more easy to prove the evolution of new species as a consequence than it is when intercrossing has been prevented by physiological barriers; for in the latter case the older and the newer forms will probably continue to occupy the same area, and thus there will be no independent evidence to show that the severance between them was due to the prevention of intercrossing. Nevertheless, all the evidence which I have of the large part that geographical barriers and migration have played in the evolution of species by the prevention of intercrossing with parent forms, goes to show the probable importance of physiological barriers when acting in the same way. Hence it will be better to postpone this line of argument till the appearance of my next paper, where I shall hope to show, from evidence furnished by the geographical distribution of species, how predominant a part the prevention of intercrossing has played in the evolution of species. Here, therefore, it will be enough to offer a few general remarks.

In the first place, the theory of physiological selection has this great advantage over the theory of natural selection, namely, that the swamping effects of free intercrossing on the new variety—or on the incipient species—are supposed to be from the first excluded by the very fact of the variation itself. This is so obvious an advantage that it appears needless to dwell upon its consideration.

But, in the next place, I may observe that, in so many cases as species do originate by physiological selection, the subsequent influence of natural selection admits of being considerably enhanced. For when once this physiological separation between a variety and its parent-stock has been effected, there will be less likelihood than before of any useful variations which may subsequently arise in the former being again obliterated by intercrossing. This is evident, because the possibilities of intercrossing would now be restricted to a much smaller number of individuals, and therefore the influence of intercrossing would not be so detrimental to the continuance of any beneficial variation. In other words, the primary variation of the reproductive system would serve to protect any secondary variations of a useful kind which might afterwards arise elsewhere; just as happens in the analogous case where intercrossing is prevented by geographical barriers, or by migration in different directions of varying descendants from a common centre.

And here we catch sight of another respect in which physiological selection probably cooperates with natural selection. As previously remarked, Mr. Darwin felt profoundly the strength of this objection from sterility between species, and, I may now add, he tried to imagine some way in which the general fact of such sterility might be reasonably attributed to natural selection. If he could have done this, of course he would have mitigated the difficulty; for, as he writes, "it would clearly be advantageous to two varieties or incipient species if they could be kept from blending, on the same principle that, when man is selecting at the same time two varieties, it is necessary that he should keep them separate." But, as the result of his discussion, he concludes:—"In considering the probability of natural selection having come into action in rendering species mutually sterile, the greatest difficulty will be found to be in the existence of many graduated steps from slightly lessened fertility to absolute sterility. It may be admitted that it would profit an incipient species, even if it were rendered in some slight degree sterile when crossed with its parent-form or with some other variety; for thus fewer bastardized and deteriorated offspring would be produced to commingle their blood with the new species in process of formation. But he who will take the trouble to reflect on the steps by which this first degree of sterility could be increased through natural selection to that high degree which is common with so many species, will find the subject extraordinarily complex. After mature reflection it appears to me that this could not have been effected through natural selection."

Now, with this conclusion I fully agree; but it will by this time be clearly seen that what cannot be effected by natural selection may well be effected by physiological selection. For both the considerations which Mr. Darwin here candidly adduces as insuperable difficulties in the way of supposing sterility due to natural selection, are just the considerations which most strongly favour the hypothesis of physiological selection. These two considerations are, first, "the many graduated steps from slightly lessened fertility to absolute sterility," and, second, "the steps by which this first degree of sterility would be increased." Now, as already shown in a previous part of this paper, these "many graduated steps" are just what we might expect to find on the theory of physiological selection; while, upon this theory, there is no need to suppose that "the first degree of sterility" must necessarily go on increasing. In

whatever degree the sterility first occurs, in that degree it may remain; for, *ex hypothesi*, it must from the first have been sufficient to cause at least so much of physiological separation of the varietal type as to admit of the continuance of that type. If this degree of sterility were from the first but small, a longer time would be required to effect a complete separation between the parent and the variety, than if this degree were from the first considerable. But, as we have before seen, this is all the difference that would arise; and therefore, upon my theory, we may regard degrees of sterility as matters of no significance—although I do think it is extremely probable that when once sterility in any degree has arisen it will afterwards become increased, not so much for the reason assigned by Mr. Darwin (viz. prolonged exposure to uniform conditions), as from the general tendency which variations of all kinds present to continue in the lines of their initial deviation. I cannot doubt that if the theory of physiological selection had occurred to Mr. Darwin, he would have seen in this latter consideration a much more cogent reason than the one which he assigns for the general sterility that obtains between species. But he was precluded from applying this consideration because it did not occur to him that sterility might itself be originally due to independent variation, and thus itself be subject to the laws of variation in general.

I trust, then, that these considerations will have shown that, although natural selection cannot have been directly instrumental in causing sterility between an incipient species and its parent form, if the incipient species were such in virtue of a variation in its reproductive system tending from the first to prevent intercrossing with its parent form, then there would be a variation the further development of which might be favoured by natural selection. For if, as Mr. Darwin thought, "it would profit an incipient species if it were rendered in some degree sterile with its parent form," although this profit could not have been initially conferred by natural selection, yet when it once arises from a spontaneous variation in the reproductive system itself, I see no reason to doubt that it should forthwith be favoured by natural selection, just as is the case with favourable variations in general. That is to say, natural selection would set a premium upon infertility with the parent form, and would thus cooperate with physiological selection in splitting up the specific type. For, although natural selection is powerless to induce sterility between allied forms,

when once this sterility is given as an independent variation, the forms—though not necessarily the *individuals*—which profit by it would be favoured by natural selection in their competition with other forms which do not present such variation. In short, once let intercrossing with the parent-type be prevented by physiological selection, and the field is at once thrown open to the further or cooperating influence of natural selection—whether this be effected directly, as here supposed, or indirectly by modifying the reproductive system through the rest of the organism, as previously supposed. Later on, under Divergence of Character, I will show another and much more important respect in which physiological selection, by preventing intercrossing with parent forms, is able to assist natural selection in the differentiation of specific types.

Argument from the Inutility of Specific Differences.

With reference to inutility, after what has already been said, I will only repeat this somewhat important question,—Why is it that apparently useless structures and instincts occur in such profusion among species, in much less profusion among genera, and scarcely at all among families, orders, and classes? To this question the Darwinist can only answer that the utility of apparently useless structures really is less than that of structures whose utility is observable. For although the argument from ignorance may be available up to a certain point, it clearly cannot be available to the extent of showing why useful structures within the limits of species should have their utility more disguised than useful structures elsewhere. Hence the Darwinist can only conclude that, at all events the majority of structures which he assumes to be useful in the case of species are not *seen* by him to be useful, because their utility actually *is* less than in the case of structures distinctive of genera, families, and so forth. He must argue that the points wherein species differ from species —being points of smaller detail than those which serve to distinguish genera, families, &c.—present less opportunity of usefulness; and, therefore, as a rule, actually are of too little use to admit of their utility being diagnosed, although not of so little use as to have prevented their development by natural selection, which is a better diagnostitian of utility than the naturalist. But how much more probable is the answer which

may be furnished by any one who accepts the theory of physiological selection. For, upon this theory, it is quite intelligible that when a varietal form is differentiated from its parent form by the bar of sterility, any little meaningless peculiarities of structure or of instinct should at first be allowed to arise, and that they should then be allowed to perpetuate themselves by heredity, until—not being conserved by natural selection—they should be again eliminated as so much surplusage in the struggle for existénce, whether by the economy of growth or by independent variation when undirected by natural selection. A greater or less time would in different cases be required to effect this reduction; and thus we can understand how it is that any useless structures which do not impose much tax upon the organism occasionally persist even into genera, but rarely into families, or higher taxonomic divisions.

This appears to me much the most probable view, not merely on *à priori* grounds, but also for the following reasons. I have just said that if apparently useless structures (whether these be new structures or modifications of old ones, slight changes of form, colour, and so forth) are thus to be regarded as really useless, or as meaningless variations not yet eliminated by natural selection or other agencies,—I have said that, if this is so, these apparently useless structures must be of a kind which do not impose much tax upon the organism. Now I have applied this test, and I find it is almost an invariable rule (both in plants and animals) that apparently useless structures are structures of this kind. Either on account of their small size or of their organically inexpensive material, they are structures which do not impose any such physiological tax upon the organism as should lead us to expect their speedy removal. But surely there can be no imaginable association between utility as disguised and smallness of size, or inexpensiveness of material. Whereas, no less surely, there is a most obvious connection between these things and a *real* inutility. Thus, it is only a blind prepossession in favour of survival of the fittest as in all cases the originating cause of species that can lead to so irrational an assumption as that of universal utility.

Again, even apart from all the above considerations, the truth of this remark may be well exemplified within the limits of Mr. Darwin's own writings; for Mr. Darwin is here, as usual, his own best critic. He says, "In the earlier editions of this work I

underrated, as it now seems probable, the frequency and importance of modifications due to spontaneous variability"*, by which he means unuseful modifications. And he proceeds to give a number of examples.

Elsewhere (p. 158) he points out that modifications which appear to present obvious utility are found on further examination to be really useless. This latter consideration, therefore, may be said to act as a foil to the one against which I am arguing, viz. that modifications which appear to be useless may nevertheless be useful. But here is a still more suggestive consideration, also derived from Mr. Darwin's writings. Among our domesticated productions, changes of structure—or even structures wholly new—not unfrequently arise which are in every way analogous to the apparently useless distinctions between wild species. Take, for example, the following most instructive case:—

"Another curious anomaly is offered by the appendages described by M. Eudes-Deslongchamps as often characterizing the Normandy pigs. These appendages are always attached to the same spot, to the corners of the jaws; they are cylindrical, about three inches in length, covered with bristles, and with a pencil of bristles rising out of a sinus on one side; they have a cartilaginous centre with two small longitudinal muscles; they occur either symmetrically on both sides of the face, or on one side alone. Richardson figures them on the gaunt old 'Irish Greyhound pig;' and Nathusius states that they often occasionally appear in all the long-eared races, but are not strictly inherited, for they occur or fail in the animals of the same litter. As no wild pigs are known to have analogous appendages, we have at present no reason to suppose that their appearance is due to reversion; and if this be so, we are forced to admit that a somewhat complex, though apparently useless, structure may be suddenly developed without the aid of selection"†.

Now, if any such structure as this occurred in a wild species, and if any one were to ask what is the use of it, those who rely on the argument from ignorance would have a much stronger case than they usually have; for they might point to the cartilage supplied with muscles, and supporting a curious arrange-

* 'Origin of Species,' ed. 6, p. 171. Also, and even more strongly, 'Descent of Man,' p. 367.

† 'Variation,' &c. vol. i. pp. 78–9.

ment of bristles as much too specialized a structure to be wholly meaningless. Yet we happen to know that this particular structure is wholly meaningless. What, then, are we to say to the argument from ignorance in other and less cogent cases? I think we must say that the argument is wholly untrustworthy in fact, while even in theory it can only stand upon the assumption (latterly discarded even by Darwin himself) that all specific differences must be due to natural selection.

Argument from Divergence of Character.

Any theory of the origin of species in the way of descent must be prepared with an answer to the question, Why have species *multiplied*? How is it that, in the course of evolution, species have not simply become transmuted in linear series instead of ramifying into branches? This question Mr. Darwin seeks to answer "from the simple circumstance that the more diversified the descendants from any one species become in structure, constitution, and habits, by so much will they be better enabled to seize on many and widely diversified places in the economy of nature, and so be enabled to increase in numbers."* And he proceeds to illustrate this principle by means of a diagram, showing the hypothetical divergence of character undergone by the descendants of seven species. Thus, he attributes divergence of character exclusively to the influence of natural selection.

Now, this argument appears to me unassailable in all save one particular; but this is a most important particular: the argument wholly ignores the fact of intercrossing with parent forms. Granting to the argument that intercrossing with parent forms is prohibited, and nothing can be more satisfactory. The argument, however, sets out with showing that it is in limited areas, or in areas already overstocked with the specific form in question, that the advantages to be derived from diversification will be most pronounced. Or, in Mr. Darwin's words, it is where they "jostle each other most closely" that natural selection will set a premium upon any members of the species which may depart from the common type. Now, inasmuch as this jostling or overcrowding of individuals is a needful condition to the agency of natural selection in the way of diversifying character, must we not feel that the general difficulty from intercrossing previously

* 'Origin of Species,' ed. 6, p. 87.

considered is here presented in a special and aggravated form? At all events, I know that, after having duly and impartially considered the matter, to me it does appear that unless the swamping effects of intercrossing with the parent form on an overcrowded area is in some way prevented, to begin with, natural selection could never have any material supplied by which to go on with. Let it be observed that I regard Mr. Darwin's argument as perfectly sound where it treats of the divergence of *species*, and of their further divergence into *genera*; for in these cases the physiological barrier is known to be already present. But in applying the argument to explain the divergence of *individuals* into *varieties*, it seems to me that here, more than anywhere else, Mr. Darwin has strangely lost sight of the formidable difficulty in question; for in this particular case so formidable does the difficulty seem to me, that I cannot believe that natural selection alone could produce any divergence of specific character, so long as all the individuals on an overcrowded area occupy that area together. Yet, if any of them quit that area, and so escape from the unifying influence of free intercrossing *, these individuals also escape from the conditions which Mr. Darwin names as those that are needed by natural selection in order to produce divergence. Therefore, it appears to me that, under the circumstances supposed, natural selection alone could not produce divergence; the most it could do would be to change the whole specific type in some one direction (the needful variations in that one direction being caused by some general change of food, climate, habit, &c., affecting a number of individuals simultaneously), and thus induce transmutation of species in a linear series, each succeeding member of which might supplant its parent form. But in order to secure diversity, multiplication, or ramification of species, it appears to me obvious that the primary condition required is that of preventing intercrossing with parent forms at the origin of each branch, whether the prevention be from the first absolute, or only partial. And, after all that has been previously said, it is needless again to show that the principles of physiological selection are at once the only principles which are here likely to be efficient, and the principles which are fully capable of doing all that is required. For species, as they now

* As Mr. Darwin elsewhere observes, "Intercrossing plays a very important part in nature by keeping the individuals of the same species, or of the same variety, true and uniform in character" (p. 81).

stand, unquestionably prove the fact of ramification; and it appears to me no less unquestionable that ramification, as often as it has occurred, can only have been permitted to occur by the absence of intercrossing with parent forms. But, apart from geographical barriers (which, according to Mr. Darwin's argument, would be inimical to the divergence of character by natural selection), the ramification can only take place as a consequence of physiological selection, or as a consequence of some change in the reproductive system which prevents intercrossing with unchanged (or differently changed) compatriots. But when once this condition is supplied by physiological selection, I have no doubt that divergence of character may then be promoted by natural selection, in the way that is explained by Mr. Darwin.

And this latter consideration is a most important one for us to bear in mind, because it furnishes an additional reason for the fact that when a section of a species has become physiologically separated from the rest of its species, it forthwith begins to run into variations of other kinds, and so eventually to differ from the parent type, not only as regards the primary distinction of sterility, but also as regards secondary distinctions which may affect any part of the organism. The only reasons which I have hitherto assigned for this fact are, first, that from the time when overwhelming intercrossing with the parent form is prevented, the varietal form is allowed to develop an independent course of varietal history, as in the parallel case where intercrossing is prevented by geographical barriers, or by migration; and, second, that when the primary variation takes place in the reproductive system, it is apt to cause secondary variations in the progeny. But now I may make this important addition to those reasons—the addition, I mean, that when intercrossing with a parent form is in any degree prevented by physiological selection, the varietal form is free to develop diversity of character under the influence of natural selection, in the way that has been so ably shown by Mr. Darwin.

From which it will be seen that the theory of physiological selection has this advantage over the theory of natural selection in the way of explaining what Mr. Darwin calls diversification of character, or what I have called the ramification of species. This diversification or ramification has reference chiefly to the secondary specific distinctions which, as we have seen, the theory of natural selection supposes to be the first changes that occur, and

by their occurrence to induce the primary distinction of sterility. My theory, on the other hand, inverts this order, and supposes the primary distinction to be likewise, as a rule, the primordial distinction. Now, the advantages thus gained are two-fold. In the first place, as just shown, we are able to release the principles of natural selection from what appears to me the otherwise hopeless difficulty of effecting diversification of specific character on an overcrowded area, with nothing to prevent free intercrossing; and, in the next place, as we can now see, we are able to find an additional reason for the diversification of character, over and above the one that is relied upon by Mr. Darwin. For, by regarding the primary distinction of sterility as likewise the primordial distinction, we are able to apply to an incipient variety, inhabiting even an overcrowded area, the same principles which are known to lead to diversification on oceanic islands, &c., as previously explained. Moreover, from any initial variation on the part of the reproductive system, we should be prepared to expect variations to occur in other parts of the progeny. Thus, if once we regard the primary distinction of sterility as also the initial distinction, instead of an incidental result of secondary distinctions, Mr. Darwin's argument touching the causes of diversification is not merely saved: it is notably extended by the addition of two independent principles which, as we know from other evidence, are principles of high importance in this respect.

Argument from Geographical Distribution.

From the nature of the case, there is only one other line of evidence open whereby to substantiate the theory of physiological selection, namely, the evidence which is afforded by the geographical distribution of species. But the evidence here is both abundant in quantity and, to my mind, most cogent in quality. On the present occasion, however, I can only give a brief sketch of its main outlines.

Mr. Darwin has adduced very good evidence to show that large areas, notwithstanding the disadvantages which (on his theory) must arise from free intercrossing, are what he terms better manufactories of species than smaller areas, such as oceanic islands. On the other hand, I have previously noticed that oceanic islands are comparatively rich in peculiar species. But these two statements are not incompatible. Smaller areas are, as a rule, rich in peculiar species relatively to the number of

their inhabitants; but it does not follow that they are rich in species if contrasted with larger areas containing very many more inhabitants. Therefore, the rules are that large areas turn out an absolutely greater number of specific types than small areas; although, relatively to the number of individuals or amount of population, the small areas turn out a larger number of species than the large areas.

Now, these two complementary rules admit of being explained as Darwin explains them. Small and isolated areas are rich in species relatively to the amount of population, because, as we have before seen, this population has been permitted to develop an independent history of its own, shielded from intercrossing with parent, and from struggle with exotic forms. On the other hand, large and continuous areas are favourable to the production of numerous species, first, because they contain a large population, so favouring the occurrence of numerous variations; and, secondly, because the large area furnishes a diversity of conditions in its different parts, as to food, climate, altitude, and so forth.

Such being the state of the facts, it is obvious that physiological selection must have what may be termed a first-rate opportunity of assisting in the manufacture of species on large areas. For, not only is it upon large and continuous areas that the antagonistic effects of intercrossing are most pronounced (and, therefore, that the influence of physiological selection must be most useful in the work of species-making); but here also the large population, as well as the diversity in the external conditions of life which the large area supplies to different parts of that population,—both these circumstances cannot fail to furnish physiological selection with a greater abundance of that particular variation in the reproductive system on which its action depends. For all these reasons, therefore, we might have expected, upon my theory, that large and continuous areas should be good manufactories of species.

Again, Mr. Darwin has shown that not only large areas, but likewise "dominant" genera upon those areas, are rich in species. By dominant genera he means genera represented by numerous individuals, as compared with other genera inhabiting the same area. This general rule he explains by the consideration that the qualities which first led to the form being dominant must have been useful qualities; that these would be transmitted to the otherwise varying offspring; and, therefore, that when these

offspring had varied sufficiently to become new species, they would still enjoy their ancestral advantages in the struggle for existence. And this, I doubt not, is in part a true explanation; but I also think that the reason why dominant genera are rich in species is chiefly because they everywhere present a great number of individuals exposed to relatively great differences in their conditions of life, or, in other words, that they furnish the best raw material for the manufacture of species by physiological selection, as explained in the last paragraph. For, if the fact of dominant genera being rich in species is to be explained *only* by natural selection, it appears to me that the useful qualities which have already led to the dominance of the ancestral type ought rather to have proved inimical to its splitting up into a number of subordinate types. If already so far "in harmony with its environment" as to have become for this reason dominant, one would suppose that there is all the more reason for its not undergoing change by the process of natural selection. Or, at least, I do not see why the fact of its being in an unusual degree of harmony with its environment should in itself constitute any unusual reason for its modification by survival of the fittest. On the other hand, as just observed, I do very plainly see why such a reason is furnished for the modifying influence of physiological selection.

Let us next turn to another of Mr. Darwin's general rules with reference to distribution. He took a great deal of trouble to collect evidence on the two following facts, namely: 1st, that "species of the larger genera in each country vary more frequently than the species of the smaller genera"; and 2nd, that "many of the species included within the larger genera resemble varieties in being very closely, but unequally, related to each other, and in having restricted ranges."* By larger genera he means genera containing many species; and he accounts for these general facts by the principle "that where many species of a genus have been formed, on an average many are still forming." But how forming? If we say by natural selection alone, we should expect to find the multitudinous species differing from one another in respect of features presenting utilitarian significance; yet this is precisely what we do not find. For Mr. Darwin's argument here consists in showing that "in large genera the amount of difference between the species is often exceedingly

* 'Origin of Species,' ed. 6. pp. 44, 45.

small, so that in this respect the species of the larger genera resemble varieties more than do the species of the smaller genera." Therefore the argument, while undoubtedly a very forcible one in favour of the fact of *evolution*, appears to me scarcely consistent with the theory of *natural selection*. On the other hand, the argument tells strongly (though unconsciously) in favour of physiological selection. For the larger a genus, or the greater the number of species it contains, the greater must be the opportunity afforded for the occurrence of that particular kind of variation on which the principle of physiological selection depends. All the species of a genus may be regarded as so many varieties which have already been separated from one another physiologically; therefore each of them may now constitute a new starting-point for a further and similar separation—particularly as, in virtue of their previous segregation, many of them are now exposed to different conditions of life. Thus, it seems to me, we can well understand why it is that genera already rich in species tend to grow still richer; while such is not the case in so great a degree with genera that are poor in species. Moreover, we can well understand that, multiplication of species being in the first instance determined by changes in the reproductive system alone, wherever a large number of new species are being turned out, the secondary differences between them should be "often exceedingly small"—a general correlation which, so far as I can see, we are not able to understand on the theory of natura selection.

The two subsidiary facts, that very closely allied species have restricted ranges, and that dominant species are rich in varieties, both seem to tell more in favour of physiological than of natural selection. For "very closely allied species" is but another name for species which scarcely differ from one another at all except in their reproductive systems; and, therefore, the more restricted their ranges, the more certainly would they have become fused by intercrossing with one another, had it not been for the barrier of sterility imposed by the primary distinction. Or rather, I should say, had it not been for the original occurrence of this barrier, these now closely-allied species would never have become species. Again, that dominant species should be rich in varieties is what might have been expected; for the greater the number of individuals in a species, the greater is the chance of variations taking place in all parts of the organic type, and particularly in the

reproductive system, seeing that this system is the most sensitive to small changes in the conditions of life, and that the greater the number of individuals composing a specific type, the more certainty there is of some of them encountering such changes. Now, of all the variations going on in all parts of the organic type, those which occur in the reproductive system of the kind required by physiological selection are most likely to be preserved, seeing that all other variations are likely to be swamped by free intercrossing. Hence, the richness of dominant species in varieties is, I believe, mainly due to the greater opportunity which such species afford of some degree of sterility arising between its constituent members.

Here is another general fact, also first noticed by Darwin, and one which he experiences some difficulty in explaining on the theory of natural selection. He says:—"In travelling from north to south over a continent, we generally meet at successive intervals with closely-allied or representative species, evidently filling the same place in the economy of the land. These representative species often meet and interlock, and as one becomes rarer and rarer, the other becomes more and more frequent, till the one replaces the other. But if we compare these species where they intermingle, they are generally as absolutely distinct from each other in every detail of structure as are specimens taken from the metropolis of each. . . . . . In the intermediate region, having intermediate conditions of life, why do we not now find closely-linking intermediate varieties? This difficulty for a long time quite confounded me. But I think it can in large part be explained"*.

This explanation is that, as "the neutral territory between two representative species is generally narrow in comparison with the territory proper to each, ... and as varieties do not essentially differ from species, the same rule will probably apply to both; and, therefore, if we take a varying species inhabiting a very large area, we shall have to adapt two varieties to two large areas, and a third variety to a narrow intermediate zone." It is hence argued that this third or intermediate variety, on account of its existing in lesser numbers, will probably be soon overrun and exterminated by the larger populations on either side of it. But surely this argument overlooks one all-important fact, namely, that varieties *do* "essentially differ from species" in

* 'Origin of Species,' ed. 6, pp. 134–135.

respect of being able freely to intercross with one another. Therefore, how is it possible "to adapt two varieties to two large areas, and a third (transitional) variety to a narrow intermediate zone," in the face of free intercrossing on a continuous area? Let A, B, and C represent the three areas in question. According

to the argument, variety A passes first into variety B, and then into variety C, while variety B eventually becomes exterminated by the inroads both from A and C. But how can all this have taken place with nothing to prevent intercrossing throughout the entire area A B C? I confess that to me it seems this argument can only hold on the supposition that the analogy between varieties and species extends to the reproductive system; or, in a sense more absolute than the argument has in view, that "varieties do not essentially differ from the species" which they afterwards form, but from the first showed some degree of sterility towards one another. And, if so, we have of course to do with the principles of physiological selection.

That in all such cases of species-distribution these principles have played an important part in the species-formation, appears to be rendered further probable from the suddenness of transition on the area occupied by contiguous species, as well as from the completeness of it—*i. e.* the absence of connecting forms. For all these facts combine to testify that the transition was originally due to that particular change in the reproductive systems of the forms concerned, which still enables those forms to "interlock" without intercrossing.

But this leads us to another general fact, also mentioned by Darwin, and well recognized by all naturalists, namely, that closely allied species, or species differing from one another in trivial details, usually occupy contiguous areas; or, conversely stated, that contiguity of geographical position is favourable to the appearance of species closely allied to one another. Of course this fact speaks in favour of evolution; but where the question is as to method, I confess that the theory of natural selection appears to me wholly irrevelant. For in all the numberless cases to which I allude, the points of minute detail wherein the allied species differ in respect of secondary distinctions are points

which present no utilitarian significance. And, as previously argued, it is impossible to believe that there can be any general or constant correlation between disguised utility and insignificance of secondary distinction.

Now, the large body of facts to which I here allude, but will not at present wait to specify, appear to me to constitute perhaps the strongest of all my arguments in favour of physiological selection. Take, for instance, a large continental area and follow across it a chain of species, each link of which differs from those on either side of it by the most minute and trivial distinctions of a secondary kind, but all the links of which differ from one another in respect of their reproductive systems, so that no one member of the series is perfectly fertile with any other member. Can it be supposed that in every case this constant primary distinction has been superinduced by the trivial secondary distinctions, distributed as they are over different parts of all these kindred organisms, and yet nowhere presenting any but the most trifling amount of morphological change? Or, even if we were to suppose this, we have still to meet the question, How were all these trifling changes produced in the face of free intercrossing on the continuous area? Certainly not by natural selection, seeing that they are useless to the species presenting them. Let it then be by changes in the conditions of life, whether of food, of climate, or of any thing else. I can conceive of no other alternative. Yet if we accept this alternative, we are but espousing—in a disguised and roundabout way to be sure—the theory of physiological selection. For we are thus but hypothetically assigning the causes which have induced the primary distinction in each case, or the causes which have led to the mutual sterility. For my own part, I believe that the assignation would be, in the great majority of such cases, incorrect. That is to say, for reasons already given, I do not believe that in the great majority of such cases the trivial secondary distinctions, howsoever these were caused, can have had any thing to do with the great primary distinction. What I believe is, that all the closely allied species inhabiting our supposed continent, and differing from one another in so many points of minute detail, are but so many records of one particular kind of variation having taken place in the reproductive systems of their ancestors, and so often as it did take place, having necessarily given birth to a new species. The primary distinc-

tion thus became the constant distinction, simply because it was in virtue of this distinction, or in virtue of the variation which first originated this distinction, that the species became species; and the secondary distinctions thus became multitudinous, minute, and unmeaning, simply because they were of later origin,—the result of spontaneous variability, unchecked by intercrossing with the parent forms, and, on account of their trivial (*i. e.* physiologically harmless) nature, unchecked also by natural selection, economy of growth, or any other principle which might have prevented spontaneous variability of any other kind.

Relations between Survival of the Fittest and Segregation of the Fit.

In several preceding parts of this paper, I have had occasion to notice some of the relations between the two forms of selection, natural and physiological. But it seems desirable to consider this matter a little more closely.

First of all, it will have been observed that the theory of physiological selection in some respects resembles and in other respects differs from that of natural section. Thus to some extent the two theories resemble one another in the kind of evidence by which they are each supported. In neither case does the theory rest upon any actual observation of the origin of species by the agency supposed; in both cases, therefore, the evidence of the agency is deduced from general considerations regarding the morphology and distribution of specific forms, as well as the observable relations in which such forms now stand to one another. Thus, in the case of each theory alike, the argument takes the form of first establishing a *prima facie* case, showing the antecedent probability of the cause in question; and next in proving, by a general survey of organic nature, that many of the facts are such as they ought to be if the theory in question is true.

So far, then, the two theories are logically similar in form; but in certain material points they widely differ.

To begin with, it is obvious that as natural selection is a theory of the origin of adaptations, it is a theory of the origin of genera, families, orders, and classes, quite as much as it is a theory of the origin of species. Indeed, as I have already given reasons to show, it appears to me that natural selection is much more a

theory of the origin of genera, families, orders, and classes, than it is a theory of the origin of species. Physiological selection, on the other hand, is almost exclusively a theory of the origin of species, seeing that it can but very rarely have had anything to do with the formation of genera, and can never have had anything at all to do with the formation of families, orders, or classes. Hence, the evidence which we have of the evolutionary influence of physiological selection, unlike that which we have of the evolutionary influence of natural selection, is confined within the limits of specific distinctions.

Again, physiological selection differs from natural selection in that the variations on the occurrence of which it depends are variations of an unuseful kind. But, if the princi ple acts atll, it must resemble natural selection in being quite as vigilant in the selection, and quite as potent in the formation of organic types; seeing that any variation in the reproductive system of the kind in question must be preserved by the principle in question, and this with even more certainty than are the useful variations which furnish material to the working of natural selection. For while these useful variations—especially in their incipient stages, when few in number and unpronounced in character—are obviously exposed to the most serious risk of extinction from intercrossing, there is no such risk in the case of this non-useful variation. Here the obliterating effects of intercrossing on the new variety are from the first excluded by the very fact of its being a variety, or in virtue of the very peculiarity which distinguishes it as a variety. Physiological selection therefore, has this great advantange over natural selection,—although it is confined to selecting only one kind of variation, and this only in the reproductive system, whenever this one kind of variation occurs it cannot escape the preserving agency of physiological selection. Hence, even if it be granted that the variation which affects the reproductive system in this particular way is a variation of comparatively rare occurrence, still, as it must always be preserved whenever it does occur, its influence in the manufacture of specific types must be cumulative, and, therefore, in the course of geological time, probably immense.

So much, then, for the resemblances and the differences between the two theories. It only remains to add that the two are complementary. I have already shown some of the respects in which the newer theory comes to the assistance of the older, and this in

the places where the older has stood most in need of assistance. In particular, I have shown that segregation of the fit entirely relieves survival of the fittest from the difficulty under which it has hitherto laboured of explaining why it is that sterility is so constantly found between species, while so rarely found between varieties which differ from one another even more than many species; why so many features of specific distinction are useless to the species presenting them; and why it is that incipient varieties are not obliterated by intercrossing with parent forms. Again, we have seen that physiological selection, by preventing such intercrossing, enables natural selection to promote diversity of character, and thus to evolve species in ramifying branches instead of in linear series—a work which I cannot see how natural selection could possibly perform unless thus aided by physiological selection. Moreover, we have seen that although natural selection alone could not induce sterility between allied types, yet when this sterility is given by physiological selection, the forms which present it would be favoured in the struggle for existence; and thus again the two principles are found playing, as it were, into each other's hands. And here, as elsewhere, I believe that the co-operation enables the two principles to effect very much more in the way of species-making than either of them could effect if working separately. On the one hand, without the assistance of physiological selection, natural selection would, I believe, be all but overcome by the adverse influences of free intercrossing—influences all the more potent under the very conditions which are required for the multiplication of species by divergence of character. On the other hand, without natural selection, physiological selection would be powerless to create any differences of specific type, other than those of mutual sterility and trivial details of structure, form, and colour—differences wholly without meaning from a utilitarian point of view. But in their combination these two principles appear to me able to accomplish what neither can accomplish alone—namely, a full and satisfactory explanation of the origin of species.

General Summary and Conclusion.

Seeing that the theory of natural selection is confessedly unable to explain the primary specific distinction of sterility, as well as a large proportional number of the secondary specific distinctions; seing also that, even as regards the remainder, it is

difficult to see how natural selection alone could have evolved them in the presence of free intercrossing; seeing all this, it becomes obvious that natural selection is not a theory of the origin of species: it is a theory of the genesis of adaptive modifications, whether these happen to be distinctive of species only, or likewise of higher taxonomic divisions. Only, if species were always distinguishable in points of utilitarian significance, if natural selection were able fully to explain the fact of their mutual sterility, and if it were a part of the theory to show that in some way the mutual crossing of varieties is prevented; only under these circumstances could it be properly said that a theory of the genesis of adaptive modifications is likewise a theory of the origin of species. But, as matters stand, supplementary theories are required. Of these the only ones hitherto suggested are the theories of use and disuse, sexual selection, correlated variability, prolonged exposure to similar conditions of life, and prevention of intercrossing by geographical barriers, or by migration. The first three may here be neglected, as they do not touch the subject-matter of the present paper. Prolonged exposure to similar conditions of life has been shown inadequate to explain the contrast between hybrids and mongrels in respect of fertility. The prevention of intercrossing by geographical barriers and by migration has been shown adequate to account for the frequent appearance of non-adaptive specific characters. But the great distinction of sterility between species is still left unexplained. This it is that my theory of physiological selection seeks to explain. And the theory consists merely in pointing to the fact that wherever, among all the possible variations of the highly variable reproductive system, there arises towards any parent form any degree of sterility which does not extend to the varietal form, there a new species must necessarily take its origin. For, even though the varietal form continues to live on the same area as its parent form, intercrossing is prevented by the primary distinction of sterility, with the consequence of secondary distinctions subsequently arising by way of independent variability—just as happens when the barrier to intercrossing, instead of being physiological, is geographical.

It makes no essential difference to my theory whether the causes of this particular variation on the part of the reproductive system are extrinsic or intrinsic; nor does it make any difference whether the variation first occurs in a high or in a low degree.

But many reasons have been given to show that most probably, in a large majority of cases, the primary distinction has likewise been the primordial distinction, and thus became the condition to the subsequent appearance of secondary distinctions by independent variability.

Moreover, one very important reason was given to show that, in all probability, the primary distinction is not only a *condition* to the subsequent appearance of secondary distinctions, but itself the *cause* of them; for Mr. Darwin has shown that when the reproductive system undergoes any variation, the consequences to progeny are apt to consist in variations affecting other parts of the organism. So that the prevention of intercrossing by physiological barriers differs from such prevention by geographical barriers, or by migration, in that, over and above the influence of independent variability, there is a direct causal connection between the agency which prevents intercrossing and the subsequent production of secondary specific characters.

Nevertheless, reasons have also been given to show that, in a small minority of cases, this historical order may have been reversed—the primary distinction having been superinduced by the secondary, as we sometimes (though very rarely) find to have been the case with our domesticated varieties, but which we usually find to have been the case with genera, &c. Even, however, when such has been the case with natural varieties living on the same area, it is the principles of physiological selection that have determined the result; for it can only have been those secondary distinctions which happened to have been able to induce the primary distinction that were, for this reason, allowed to survive. Thus in all cases where the evolution of species has not been due to the prevention of intercrossing by geographical barriers or by migration, it has probably been due to such prevention by the principles of physiological selection. Or, otherwise stated, all specific types which now display any degree of sterility towards allied types, are probably so many records of the particular variation with which we are concerned having arisen in the reproductive systems of their ancestry. For, not only has it been shown, on antecedent grounds, that the occurrence of this particular variation is in the highest degree probable, but it has also been shown that, as a matter of actual observation, it does occur in individuals, in varieties, and in species. Indeed, as regards species, the argument here resolved itself into a mere

statement of fact, namely, that all natural varieties which have not been otherwise prevented from intercrossing, and which have been allowed to survive long enough to develop any differences worth mentioning, are now found to be protected from intercrossing by the bar of sterility—that is, by a previous change or variation in the reproductive system of the kind which my theory requires. In many cases, no doubt, this particular change, or variation, has been caused by the season of flowering or of pairing having been either advanced or retarded in a section of a species, or to sundry other influences of an extrinsic kind; but probably in a still greater number of cases it has been due to what I have called intrinsic causes, or to the "spontaneous" variability of the reproductive system itself. In order to show how large a part the principles thus explained have probably played in the evolution of species, many arguments, which it would be tedious again to enumerate, have been drawn from the inutility of so large a proportion of secondary specific distinctions, from the swamping effects of intercrossing in the absence of physiological barriers, from the multiplication of species, and from the leading or most general facts of geographical distribution. Lastly, the relations between natural and physiological selection have been shown to be co-operative, the latter allowing the former to act by interposing its laws of sterility, with the result that secondary specific distinctions may be either adaptive or non-adaptive in character. On the other hand, natural selection may assist physiological selection by setting a premium both on the primary and on the secondary distinctions—*i e.* encouraging the work both of sterilizing species and of diversifying their characters.

In conclusion, therefore, it seems to me almost impossible to doubt, when so many large and general facts combine in pointing to the principles of physiological selection, that these principles must be accredited with a highly important share in the evolution of species. Mr. Darwin has well said, "From the laws governing the various grades of sterility being so uniform throughout the animal and vegetable kingdoms, we may infer that the cause, whatever it may be, is the same, or nearly the same, in all cases." This cause, as he candidly shows in the paragraphs from which the quotation is made *, obviously cannot have been natural selection. But to my mind it appears no less obvious that the

* 'Origin of Species,' ed. 6. p, 248.

cause in question is the cause which I have termed physiological selection. For what are the effects which stand to be explained? Broadly stated, these effects are simply millions and millions of cases where there is a constant association between secondary specific characters, whether useful or unuseful, and the primary specific characters of sterility with allied forms. Be it observed that all these innumerable cases are alike in *kind*, however much they may differ in regard to the *degree* of sterility. In a considerable proportion of cases there is no sterility at all, and from this zero level we encounter all degrees of it, until we reach the maximum degree, where sterility is absolute.

Now, we have seen that these differences are exactly what my theory requires. For, 1st, in a considerable proportion of cases intercrossing has been prevented by geographical barriers and by migration; in these cases, therefore, physiological selection has had nothing to do with the evolution of species, which thus continue, as we might have expected, fertile *inter se*. 2nd, in many other cases physiological selection must have been assisted in its work of preventing intercrossing, whether by partial barriers of a geographical kind, partial migrations, slight changes of climate, habitat, instinct, and so forth; in these cases, therefore, the resulting species now continue to manifest corresponding fertility between themselves, or fertility in all degrees. Hence, if sterility between allied species were always absolute, or even always considerable, the fact would be fatal to my theory; for this would show that sterility between allied forms must have been due to some cause other than the mere, but necessary, preservation of one particular kind of variation, whenever it happens to arise. But, as matters actually stand, we are able to explain the absence of sterility by the absence of physiological selection, and the presence of different degrees of sterility by the presence of different degrees of such selection.

Confining, then, our attention to that large proportional number of cases where the association in question obtains, and disregarding the different degrees of sterility, what really stands to be explained is the great and general fact of the association itself. For what does this fact imply? It implies that (the now explained exceptions apart), so soon as natural varieties become entitled to take rank as species, they are found to be varieties which, however much they may differ in other or secondary dis-

tinctions, agree in presenting the constant distinction in respect of their reproductive systems. In other words, systematists, in their classification of species, have always been engaged in unconsciously tabulating the records of cases where overwhelming intercrossing with parent forms has been prevented; and the only way in which we can account for the now very frequent occurrence of sterility between allied species is by supposing that in these cases it was this sterility which prevented the intercrossing, or constituted the condition to these species being formed. It serves still further to enforce this view of the case when we try to imagine what would happen if the now existing sterility between all allied species which present it were suddenly removed. In this case free intercrossing within the limits of each genus would soon reduce all specific types living on common areas to as small a number of species as there are now genera. But if this is what would certainly be the result on all common areas if the physiological conditions now existing were removed, must we not conclude that it was owing to the fact of these conditions that the now existing species arose?

Or, again, let us contrast the difference between natural species and domesticated varieties. These, as we have seen, resemble each other in every respect save in the one respect of mutual sterility. Can we, therefore, doubt that this condition, so often as it occurs, has played the same part in the evolution of natural species as the prevention of intercrossing by artificial barriers has played in the evolution of domesticated varieties? Or can we doubt that if intercrossing were in any other way prevented, natural species would resemble domesticated varieties still more closely in presenting well-marked differences of type without this peculiar association with the barrier of sterility? But if any one should doubt this, we have only to point to the unquestionable fact, that where intercrossing has been otherwise prevented—whether by geographical barriers or by migration—such well-marked differences of type have arisen, though in these cases they are not necessarily associated with the physiological barrier in question. Therefore, when this barrier is present, how can it be reasonable to doubt that its connection with the other differences of type is a connection of casuality? For does not this extraordinarily general connection prove that it is only those cases of variation in any other part of any organism which happen to have been associated with the physiological barrier of sterility that have

been able to survive under all circumstances where they would have otherwise inevitably perished by free intercrossing?

Looking to the very general association on which I am dwelling, I cannot wonder that in the pre-Darwinian days naturalists were led to suppose that the primary distinction of sterility was divinely accorded to species, for the purpose of preventing their secondary distinctions from becoming lost by intercrossing. And I cannot help feeling that these naturalists were less blind than their successors; for at least they had an intelligible theory whereby to explain the general association which we are considering, whereas their successors have absolutely no theory at all. They are, therefore, much in the same position as a man might be who wonders at the constant association between a flowing river and a continuously descending excavation; for in both cases the association is much too frequent and general to be accounted for by chance, so that, if it is not to be accounted for by design, there only remains the alternative of accounting for it by a connection of casuality. Yet, naturalists are now in the same state of mind as the man above supposed; they merely wonder at the association without perceiving its obvious import. For, assuredly, it is quite as obvious that species could not exist as species without the physiological condition of sterility, as it is that a river could not exist as a river without the physical condition of declivity. And just as in the latter case, wherever the requisite physical conditions occur, streams and rivers come into existence by way of natural consequence, so in the former case, wherever the requisite physiological conditions occur, species and genera arise as a no less inevitable result.

It only remains to be said that the theory of physiological selection has this immense advantage over every other theory that has ever been propounded on the origin of species: it admits of being either demonstrated or destroyed by verification. But the process of verification will be a most laborious one, and cannot be satisfactorily completed (even if many naturalists should engage upon it) without the expenditure of years of methodical research. In view of this consideration, I have deemed it best to publish my theory before undertaking the labour of verification; for, by so doing, I hope to induce other naturalists to co-operate with me in carrying on the research in different parts of the world. With this object, I will conclude by briefly

sketching out the lines on which the work of verification may proceed.

There are two main branches of testing inquiry, the one experimental, and the other systematic. It is open to the systematist, in any department either of botany or zoology, to utilize his knowledge as a specialist in the following way. Let him cast about for closely allied species which are thoroughly well separated from one another, either by geographical barriers or by migration. When he has found any two closely allied species which, for either of these reasons, he feels justified in certainly concluding can never have had an opportunity of intercrossing, let him ascertain whether they are not fertile with one another. The species ought to be as closely allied as possible, because, if they differ in any considerable degree, even though the distinction between them is nominally specific, it really approaches a distinction that is generic; and in the case of genera there is no question as to sterility being due to a general difference of organic type. Moreover, the specialist ought not to rest satisfied with only a few observations. His aim ought rather to be to make his observations over a large number of species, tabulate the results, and then see whether the average amount of sterility yielded by all his selected species is not considerably lower than a similar average obtained by selecting a similar number of closely allied species now inhabiting the same continuous area—taking care, however, to choose areas which are believed to have been continuous for long periods of time. Perhaps the best rule to follow (especially in the case of plants) would be to take species which are peculiar to oceanic islands, and to match these with allied species on mainlands, for the first set of tables; while, for the second set, allied species, both of which are peculiar to the same large continental area, should be chosen. If these observations were made over a considerable number of cases, I should expect them to show an unmistakable difference in the results of the two sets of averages. But it would be necessary to make them over a considerable number of cases, because by this method of inquiry we could never be sure that all modifying conditions had been excluded. Even if we could know the life-histories of each species chosen, there would still remain the element of doubt which is incidentally mentioned by Mr. Darwin in another connection—namely, that "if a species was rendered sterile with some one compatriot, sterility with other species would (? might)

follow as a necessary contingency." So that, in view of these considerations, I am disposed to think that even wholly negative results yielded by this branch of inquiry would not be absolutely fatal to my theory, although, no doubt, most damaging to its probability.

The other branch of inquiry consists in looking out for cases of two well-marked natural varieties living together on the same area, and ascertaining by experiment whether these are not more fertile within their own limits than they are with one another. Plants would lend themselves to these experiments much more readily than animals; and in the case of plants the experiments would not be very difficult to try, while the results when obtained would be less open to doubt than those obtainable by the method above mentioned. I therefore hope that botanists in different parts of the world will deem it worth their while to see whether it is not possible to gain this direct evidence, at once of evolution as a fact, and of physiological selection as a method.

The points to be attended to in conducting these experiments are as follows.

Let the varieties be well marked, or, at least, constant within themselves; let there be no question that both the varieties are endemic as well as common to the area which they occupy. In conducting the experiments care should be taken not to disturb the natural conditions of the individuals chosen, whether by transplantation or in any other way. And, of course, it is needless to add that not only care must be taken, but certainty secured, that the only source of fertilization of the individuals chosen is that of the pollen used by the observer. The experiments, which ought to be conducted over a large number of individuals, will in every case divide themselves into four sets:—1st, fertilization of A by B; 2nd, fertilization of B by A; 3rd, of A by A; and 4th, of B by B; where A and B are the two varieties in question. In every one experiment of these four sets of experiments the seed which is yielded must be counted and sown. When all the experiments are over, let it thus be ascertained whether there is any difference in the *degrees* of fertility which have been yielded by experiments 1 and 2, and by 3 and 4 respectively.

Postscript.

In the discussion which followed the reading of this paper, certain difficulties or objections were put forward by one or two of the more eminent naturalists who happened to be present. These I answered verbally; but, inasmuch as they may also occur to readers of the paper, I will here briefly consider those among them which do not appear to have been sufficiently anticipated in the course of the preceding pages.

First, it was objected that breeding in and in has a tendency to deteriorate offspring, and therefore that physiological selection, by limiting the area of breeding, would yield a variety less able than its parent form to compete successfully in the struggle for existence. This objection, however, would only be of any force where an exceedingly small number of individuals are concerned; and even then, I think, it may be neglected, seeing that in the course of a very few generations consanguinity becomes diluted in so rapid a ratio, even in the case of species which produce but few at a birth. On this point I may refer to the 'Origin of Species,' pp. 72, 238, and 252, to show that even Mr. Darwin (who more than any other writer has insisted on the benefit arising from cross-fertilization) disregards the effects of interbreeding, where more than a very few individuals are concerned.

Next, it was objected that it could be of no *use* to a varietal type that it should be separated from the parental. I have, however, argued that the use would be three-fold: 1st, the variety would thus be started on an independent course of history; 2nd, it would therefore be able "to seize on many and widely diversified places in the economy of nature;" and, 3rd, it would derive the advantage that breeders find in keeping their strains from intercrossing. But, over and above all this, the theory of physiological selection does not require that the separation in question should be of any use; and, therefore, this objection to the theory falls to the ground as irrelevant. So long as there is no actual *detriment* arising to the variety on account of its being separated from the parent, any ideas derived from the theory of natural selection are plainly without bearing upon the subject.

Lastly, it was in effect suggested that the theory of physiological selection is merely the re-statement of a fact. For,

as I have myself argued (pp. 361, 399–400), upon the general theory of evolution it must be accepted as a fact that, so soon as varieties have diverged from their parental type sufficiently far to take rank as species, some such change in the reproductive system as that of sterility with allied forms has usually been found to have occurred. Now, it is perfectly true that this is the well-known fact, and, moreover, as I have previously endeavoured to insist, that it is the fact which more than any other stands to be explained by any theory of the origin of species. But, obviously, the theory of physiological selection is something more than a mere re-statement of this fact: it is an *explanation* of the fact in terms of evolutionary philosophy.

First, let it be observed that the supposed objection is not concerned with any question touching the validity of the evidence adduced to show that the particular kind of variation on which my theory depends does actually take place; nor is the objection concerned with any doubt as to the extent in which this variation may have operated in the origination of species. On the contrary, the objection goes upon the ground of accepting all the evidence which I have adduced upon these points, and then representing that, granting it all, it merely amounts to a re-statement of fact. Well, let the evidence be granted, and, therefore, let it be assumed that the majority of natural species are so many records of a particular kind of variation having taken place in the reproductive systems of ancestors. The issue then resolves itself into the question whether this is a mere re-statement of fact, or whether it serves to throw any new light in the way of explanation.

By an explanation I understand the pointing out of effects as due to the operation of causes. In the present instance, the effect which has to be explained is the differentiation of specific types. This I have sought to do by invoking the agency of a well-known event—viz., that of variation—and showing that whenever this cause affects the reproductive system in a particular way, a new species must arise as an effect. Now, I believe that this mode of viewing the problem as to the origin of species is not only new, but, if true, serves to solve the problem, or to explain the facts. The facts, indeed, were there before, as must always be the case before an explanation can be suggested; but an explanation consists in placing the facts in a certain relation to one another —*i. e.* in a relation of proved causality. In the present instance

this, so far as I am aware, has not been previously done. The facts of variation have been known, and the facts of specific sterility have been known; but hitherto it has not been suggested that the former may stand to the latter in the relation of cause to effect, or that when a particular kind of variation occurs in the reproductive system a new species must necessarily ensue. The very general association between mutual sterility and specific differences of other kinds has, indeed, forced itself upon the attention of naturalists; but naturalists have attempted to explain the association by this, that, and the other collateral cause, such as divine interposition, uniform conditions of life, and so forth. The present theory, on the other hand, seeks to explain this association as itself an association of cause and effect; the theory regards a species as nothing more than a variety, where the variation happens to have affected the reproductive system in a particular way—thus leading to physiological separation, and so eventually to other morphological changes, as previously argued. Now, whatever may be thought as to the probability of this explanation, to me it appears evident that it is an explanation, and not merely a re-statement of fact. For, if not, where has been the need of all that has been written for the purpose of endeavouring to explain the association? If it has ever before been recognized that species are the effects of variations in the reproductive systems of ancestry, I cannot understand why this should not have been clearly stated; and still less can I understand why, with so simple an explanation before the mind, any naturalist should have cast about for other causes of a collateral kind. What I can understand is that more evidence should be demanded of the truth of the present explanation; but this is not the point with which the objection before us is concerned.

The real standing of the matter is simply this. Evolutionists have hitherto regarded mutual sterility as one among the effects of specific differentiation, and they have therefore been led to seek for causes which might be held adequate to account for this effect. My theory, on the other hand, regards the sterility, wherever it occurs, as itself the cause of specific differentiation; and this whether the sterility be spontaneous or induced by changes going on in other parts of the organism, as previously explained. Evolutionists have hitherto failed to find the causes of which they have been in search; and, according to my view, necessarily so, inasmuch as there are no such causes to be found.

The association between specific divergence and mutual sterility has therefore appeared, in a high degree, inexplicable; so that, in Mr. Darwin's words, "the real difficulty" presented to evolutionists has been to explain why mutual sterility "has so generally occurred with natural varieties, as soon as they have been permanently modified in a sufficient degree to take rank as species"—a difficulty which he thought we were still far from solving, inasmuch as "we are far from precisely knowing the cause." But the whole of this apparently great and inexplicable difficulty has arisen on account of regarding the sterility as, in some way or another, the *consequence* of a natural variety becoming "permanently modified." Once let the point of view be changed, or once let us see in the sterility the *antecedent* of the permanent modification, and, as it appears to me, there is an end of the matter: "the real difficulty" has vanished, seeing that we are no longer "far from precisely knowing the cause" of the general association between sterility and divergence. But, if so, can it be said that the solution of such a problem, the removal of such a difficulty, or the pointing out of such a causal relation, is nothing more than a re-statement of fact? Yet this is what the objection which I am considering amounts to; for, as previously remarked, it goes upon the ground of accepting my whole argument, and questions only the character of that argument as an explanation.

It may serve to place this matter in a still clearer light if I briefly indicate one important consequence of my suggested explanation of the origin of species, and one which certainly could not arise if this explanation were nothing more than a re-statement of facts already recognized. Hitherto it has been the aim, or argumentative bias, of evolutionists to disparage—and even to ignore—the swamping influence of intercrossing; for, according to the supposition that sterility of species is an effect of morphological divergence, it obviously follows that this swamping influence of intercrossing must be held inimical to such divergence, or to the formation of new species. According to my view, on the other hand, it is just this swamping influence of intercrossing that constitutes the *raison d'être* of all species which present any degree of sterility with allied forms. For, according to my view, it is only this one particular variation in the way of such sterility which, being in virtue of its own character shielded from the swamping influence, is for this reason allowed to survive: it is the one particular variation that is

selected to constitute a new species. Intercrossing is thus regarded as standing in the same kind of relation to the genesis of species as the struggle for existence stands to that of adaptive structures: it is the destroying tendency which furnishes the needful condition to a selective process: it is the agency which obliterates all other variations, save those of a particular kind. Therefore, according to my theory of the origin of species, the greater the swamping influence of intercrossing the better must be the conditions for evolving species mutually sterile with one another; while, as we have seen, precisely the opposite consequence follows from all previous theories upon this subject.

Probably more than enough has now been said to dispose of the criticism which I am considering, or to show that the theory of physiological selection offers a real explanation of the origin of species, and does so by going to work at the very root of the problem. I will therefore only add that the real idea in the minds of those who advanced this criticism must, it appears to me, have been that my suggested explanation of the origin of species opens up another and a more ultimate problem—namely, granting that species have originated in the way supposed, what have been the causes of the particular kind of variation in the reproductive system which the theory requires? This, of course, is a perfectly intelligible question, and one that must immediately suggest itself to the mind: my failure to meet it is therefore apt to give rise to the impression that my theory is imperfect. But, as briefly stated in the paper itself, this question is really not one with which the theory of physiological selection can properly be regarded as having anything to do. This theory has only to take the facts of variation in general as granted, and then to construct out of them its suggested explanation of the origin of species. No doubt it would be most interesting to discover the causes of every variation that constitutes the beginning of a new specific character; but our inability to do this does not invalidate the theory of physiological selection, any more than it does the theory of natural selection. Objections, indeed, have been raised against the theory of natural selection on this very ground—namely, that it does not explain the causes of those variations on the occurrence of which it depends. But these objections are clearly illogical. It constitutes no part of the theory of natural selection to explain these variations; this is a problem which belongs to the future of physiology, and no doubt

we shall have long to wait before we derive much light upon it. But it is enough for the explanation which is furnished by Mr. Darwin's theory of the evolution of adaptive structures by natural selection, that the variations in question take place; and similarly as to the present theory of the evolution of species by physiological selection.

Whatever, therefore, may be thought as to the truth of this theory, or as to the extent of its applicability, it is certainly something very much more than a bare re-statement of fact. If the evidence which I have presented on these points is accepted (as it must be by the criticism with which I am dealing), the explanatory value of the theory may be estimated by the consideration that what Mr. Darwin has called the "mystery of mysteries"* ceases to be mysterious in any other sense or degree than the general fact that offspring do not always and in every respect resemble their parents. The birth of a new species becomes, for instance, less mysterious than the birth of a child with six toes, inasmuch as the variation which it implies is one of less departure from the specific type. Nay, it becomes even less mysterious than the occurrence of what I have termed individual incompatibility—a variation which, on account of its apparently trivial character, Mr. Darwin apologizes for so much as mentioning. Hence, unless it be denied that the clearing up of a mystery constitutes an explanation, the present theory is unquestionably an explanation of the only phenomena with which it is concerned. Although it makes no attempt at explaining the physiological causes which underlie the phenomena of variation in general, if the evidence which has been given be accepted, the theory does furnish a real explanation of the origin of species, by proving that there is one particular variation which, so often as it has taken place, must necessarily have constituted the originating cause of a new specific form.

* Viz.—the problem of the origin of species, which, as shown in the preceding paper, his theory of natural selection serves only in small part to explain.

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END OF THE NINETEENTH VOLUME.

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